The SCIENTIFIC MONTHLY

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THE SCIENTIFIC MONTHLY

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Contents

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Science and Technology

(From the Month's News Releases)

Predictability Flowmeter

Complete predictability of all fluids is possible with the development of a new line of predictability flowmeters. Calibration curves can be calculated directly, without experimental calibration. The only information required to obtain a calibration for a given fluid is the density and viscosity of the fluid under conditions of flow. A new teflon stop provides quick interchangeability and ball replacement. (Fairfax, Inc., Dept. SM, 17 E. 49th St., New York 17.)

Calcium Sweetener

A handy powder form of calcium sweetener, packaged in a 2-oz sifter-top container, is available to serve persons who follow low-salt as well as low-sugar diets. The powder leaves no bitter aftertaste and is non-caloric. It is not intended for use in cooking or for sweetening beverages—simply for sweetening ready-to-eat foods or fruit. One teaspoonful of powder is equivalent in sweetening power to six teaspoonfuls of sugar. (Abbott Laboratories, Dept. SM, North Chicago, Ill.)

Analytical Balance

A single-pan analytical balance (Fig. 1) minimizes operator fatigue and still gives speed, simplicity, reproducibility, and dependability. This is achieved by the location of easily manipulated, weight-control knobs and the vernier-type reading scale which is located at eye level just above the weighing pan. The instrument also incorporates two beam-arresting knobs—one on either side—to permit arresting the beam with the left or right hand. (E. Machlett & Son, Dept. SM, 220 E. 23rd St., New York 10.)

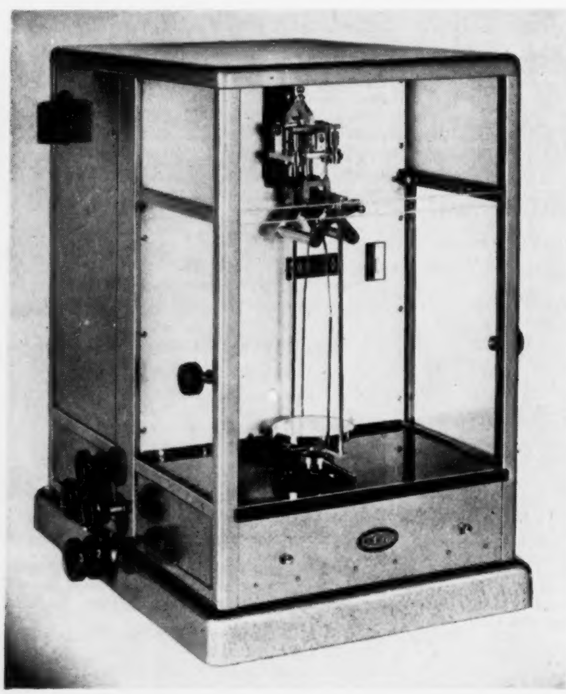

Fig. 1

Hand Tachometer

Confusion and reading errors are minimized when measuring speeds with a new hand tachometer. A novel thumb-operated range selector automatically changes the scale numbers for each range. The same mechanism also brings into view the correct number of rpm per scale division, eliminating the need to figure out the scale markings for each range. The extra long scale is subdivided for maximum readability. The tachometer insures sustained high accuracy, low operating torque, rapid response, permanent lubrication, and rugged but light-weight construction. (Metron Instrument Company, Dept. SM, 432 Lincoln Street, Denver 3, Colo.)

Micro Gram-atic Balance

A new constant-sensitivity, 20-gram-capacity microbalance embodies high speed (20-sec weighings for the two larger balances), single-pan design, two knife edges instead of three, fast air damping instead of magnetic damping, and automatically registering weights. These weights are not added but mechanically removed merely by dialing from the front panel; there is no personal handling of weights, no calculating of final results. (Fisher Scientific Company, Dept. SM, 717 Forbes Street, Pittsburgh 19, Pa.)

Vibro-Spatula

A familiar laboratory tool, the spatula, has been combined with a midget vibration motor to speed up and add accuracy to laboratory weighings. With it, particles can be dropped singly, in a steady stream, or in rapid bursts onto the weighing scoop or paper. Loosely bound aggregates of crystals can be broken up with this new tool. The motor, which vibrates a stainless-steel spatula 60 times a second, fits about as easily into the laboratorian's hands as an electric razor. (Fisher Scientific Co., Dept. SM, 717 Forbes Street, Pittsburgh 19, Pa.)

Swiss Prism Binoculars

High precision binoculars, equipped with lenses and prisms of the finest optical quality manufactured, with all air-to-glass surfaces hard coated, will render a completely color-true, stereoscopic image of greater brilliance, sharper contrasts, and maximum accuracy. They combine extremely low weight with a watchlike mechanical precision and rugged construction which has

successfully outlasted severe tests. Available models range from a unique 8 × 18 pocket model, measuring $3\frac{3}{4} \times 3\frac{1}{2} \times 1\frac{1}{4}$ in. and weighing only 7 oz, up to the still featherlight 12 × 50 (26 oz). (Karl Heitz, Inc., Dept. SM, 150 West 54th Street, New York 19.)

Silicone Resin

A newly developed, silicone, low-pressure laminating resin offers greater physical strength at both room temperature and elevated temperatures, and faster cure. It is heat stable, water repellent, inert, and resistant to oxidation and to the effects of most of the commonly used inorganic reagents. The resin has good flow characteristics and, uncatalyzed, has a gel time of 5 to 10 minutes at 250° C. (Dow Corning Corporation, Dept. SM, Midland, Mich.)

Shielded Isotope Carrier

A shielded carrier for handling bottled radioactive isotopes used in medical or research laboratories is available. The lead shield, weighing 20 lb., features a key-operated locking mechanism to prevent unauthorized personnel from handling the isotope. (Nuclear Instrument & Chemical Corporation, Dept. SM, 223–233 West Erie St., Chicago 10, Ill.)

Pencil Step-Saver

A mechanical pencil, securely held by a life-time magnet to a small strip of gold-tooled leather, will do away with any "Hold the phone while I find a pencil" annoyances. The leather plate is coated on the back with a strong, pressure-sensitive adhesive which will attach to any dry surface. The user merely lifts the pencil off the magnet—no strings, springs, nothing to get out of order. (E. J. Eller, Dept. SM, 1000 Sutter St., San Francisco 9, Calif.)

Amplifier Tube

A traveling wave amplifier tube has been designed to provide voltage amplification from 2 to 4 kmc which does not have to be tracked by a tuning voltage or mechanism. This tube finds its greatest use in applications where wideband and high gain are required at a low level, such as r.f. preamplifiers, untuned r.f. receivers, and in laboratory microwave measurement techniques. (Huggins Laboratoris, Dept. SM, 700 Hamilton Ave., Menlo Park, Calif.)

Monitoring System

Utilizing a simple inexpensive circuit, a new remote area monitoring system can make accurate radiation measurements from background to as high as 100,000 R/hr from one to ten remotely located ionization chambers. A stable low voltage battery circuit permits operation of ionization chambers up to 5000 feet from control panel without need of amplification. (Jordan Electronic Sales, Inc., Dept.SM, 119 E. Union St., Pasadena 1, Calif.)

Miniature Geiger Counter

A miniature geiger counter, hardly larger than a king-sized package of cigarettes, is now available. Accurate and highly sensitive in detecting radioactivity, this precision instrument is completely self-contained and provides continuous or intermittent service. (Cam-Mac Division, Micro Specialities Co., Dept. SM, 1834 University Ave., Berkeley 7, Calif.)

Automotive Parking Device

An automotive parking device, attached with suction cup to the bottom of the windshield of any make automobile, takes the guesswork out of parallel car parking. (Richard Whitehill & Company, Dept. SM, 6007 Euclid Ave., Cleveland, Ohio.)

Portable Pump

A gasoline–engine–powered pump, designed for multipurpose and weighing only 35 lb., has a capacity up to 8 gallons per minute open discharge and a pressure range up to 30 lb. (Hypro Engineering, Inc., Dept. KP, SM, 404 N. Washington Ave., Minneapolis 1, Minn.)

Jar Bath

A new, full-visibility jar bath (Fig. 2.) obsoletes the need for motors, stirrers, or circulating systems of any type, yet provides complete uniformity and automatic, gentle, efficient agitation in all areas of bath irrespective of work load. (Blue M Electric Co., Dept. SM, 306–08 W. 68th St., Chicago 21, Ill.)

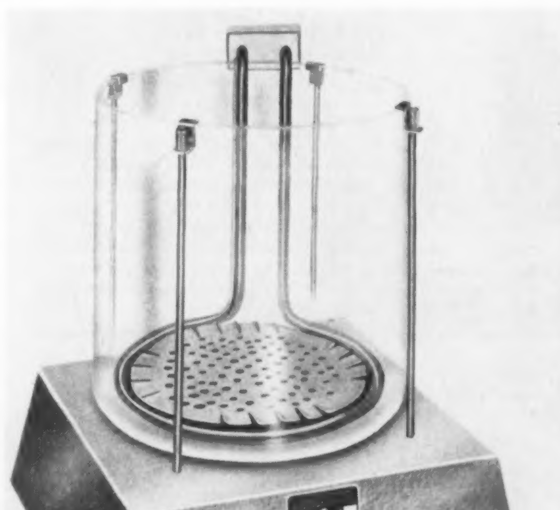

Fig. 2

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MARCH 1954

The Scientist in American Society

The four papers that follow are based on addresses given in Part II of the symposium on The Scientist in American Society *at the 1953 annual meeting of the American Association for the Advancement of Science. The program for Part II was arranged by a subcommittee of the AAAS Symposium Committee: Charles D. Coryell (chairman), P. M. Morse, and V. F. Weisskopf, all of Massachusetts Institute of Technology; and Bart J. Bok of Harvard University. Edward U. Condon, AAAS president for 1954, presided.*

Scientists and Other Citizens

GERARD PIEL

The author, publisher of Scientific American, *was born in Woodmere, Long Island, March 1, 1915. He graduated magna cum laude from Harvard University in 1937. During 1939–45, Mr. Piel was science editor for* Life *magazine, and the following year he served as assistant to the president of the Henry Kaiser Company and associated companies.*

WE may take heart in the fact that almost every recent meeting of the AAAS has featured a symposium on the double heading of science and society. One heavy price we have had to pay for the advancement of science is specialization. Scientists and other citizens have hitherto been content to live in separate worlds, almost in separate societies, to the detriment and hazard of both. It may not be too late now to discover that science is a social activity which involves other citizens as well as scientists. The fact is that science today in America is a largely socialized activity that is bringing scientists into new and not always comfortable association with their fellow citizens.

American science was never really demobilized at the end of World War II. This year expenditures on research in our universities will exceed 500 million dollars, more than 12 times prewar expenditures. Nearly nine-tenths of this money comes from government and industry. The bulk of it is for military research and almost all of it, no matter how pious the protestations of the sponsors and the scientists involved, must be credited to the support of applied, as contrasted with basic, research.

This flood of money has profoundly altered the conditions of scientific work and lives of scientists in our country. As Curt Richter of The Johns Hopkins University said in a recent issue of *Science*: "Large funds encourage great enterprises, great experimental designs. They encourage 'great teams of workers'; they take good research men away from their workbenches to direct many technicians." Worse yet, they set up pressures that divert scientists from their own work to devote their energies to the projects of others. Especially in war-motivated grants, says Professor Richter, "it is the project, the design that counts. Who does the work is often relatively unimportant."

This subordination of the scientist to the status of employee, even in an executive capacity, heavily conditions his independence. All too often it means loss of independence from within as well as from without. Unquestionably it has a role in encouraging the pre-occupation with little questions and the soft-pedaling of fruitful controversy about which scientists in every field may be heard complaining. One wonders what effect it must have upon the quality of teaching, since students traditionally take aspiration from their masters.

Their new and closer relationship to their fellow citizens thus faces scientists with a host of problems. But there is none more serious, because it compromises the possibility of action on all others, than that which confronts scientists in the realm of civil liberties. The present erosion of their academic and personal freedoms is in itself a measure of the decline of the scientist's traditional status as an independent scholar. The public record shows an increasing frequency of affronts to the integrity of scientists as citizens. In secret proceedings, many more scientists have suffered humiliation and jeopardy as the result of invasion of their freedom and privacy.

The situation must be deeply disturbing to anyone who senses the crucial relationship between the ethics and law of a free society and the conditions which are essential to the work of science. Freedom of conscience, speech, publication and assembly are required alike by the advancement of science and the self-government of a democracy. Due process in the law has its analogue in the tests of logic and evidence observed in research, and both have the purpose of arriving at the truth by induction. No scientist can surrender his freedom as a citizen without resigning his independence as a scientist. No society that muzzles political dissent will long delay the clamping of restraints upon science. In any discussion of the relationship between science and society today, these issues must come to the top of the agenda. They are the topic of legitimate professional concern, not only because they affect colleagues who have been wronged, but because they ultimately involve the freedom of every scientist to carry on his work.

Taking a broader view of this situation, two observations force themselves upon us. The first is that scientists are not alone in their plight. The constriction of the freedom of scientists is part of a general pattern which involves the freedom of people in every department of intellectual activity. The same indignities have been visited upon writers, actors, scholars, government administrators, teachers, lawyers and ministers. The present movement differs from similar episodes in the American past in that it favors intellectuals as its target.

The second observation is that this movement has its origins deep in the structure and condition of American society today. It is no mere case of democracy fumbling, as has been said, with the difficult reconciliation of security and freedom in a dangerous world. Espionage, sabotage, and treason are familiar perils to the existence of national states. Our people long ago equipped the Federal Government to deal with them by methods that accord with the institutions and ideals we want to protect. The spectacle we have been witnessing is not only repugnant to the spirit of our society but largely irrelevant to national security. In fact, according to Senator Herbert H. Lehman, this "full-scale assault on the Government service, the schools, the stage, the publishing world and even the churches" has done more harm to the national security than disclosure of all the nation's defense secrets could have done.

Nor is this the first time that conscienceless politicians have undertaken to exploit popular apprehension in a time of world unrest. They have ample precedent in our history from the XYZ papers to the Palmer raids. But the present crop of demagogues and their ignoble collaborators have been spared for too long the wrath that should spring from the sense of fair play innate in the American tradition. That is why we are moved to see these events as symptomatic of some serious malaise in our culture, of grave disturbance in our social order.

Though they are not really looking for the causes of these deeper troubles, our contemporary inquisitors seem to sense that the hunt is warmer when they have a scientist in the dock. It is, after all, quite widely understood that science does have something to do with the amenities and the troubles of living in our time.

In an address before a corresponding gathering of the British Association for the Advancement of Science last year, Alexander Macbeath, professor of logic and metaphysics at The Queen's University in Belfast, described the situation thus:

> . . . it is to the power over his environment which it placed at man's disposal, that science mainly owes its present prestige. The miracles of the modern world—motor cars and airplanes, radio and television—all derive from science; and for the mass of mankind, they constitute its justification. . . . But the dangers and discomforts which have come in their train have been equally great—high explosives and atom bombs, the squalor of urbanization, the exploitation of man by man—and it is of these that men have become painfully conscious during the 20th century. . . .

> After learning by bitter experience that [the knowledge and power that science brings] are not always used wisely, men have reacted not only against freedom to misuse them, but against freedom in general.

In fear and insecurity, the people seek the reassurance of conformity and thereby create the market for our latter day revivalists and promoters of authoritarianism. The intellectual who disturbs their uneasy peace with doubting questions comes to be regarded as a heretic, a revolutionary and worse. Hence the apathy, if not the approbation with which the public has thus far permitted the stifling of our civil liberties to advance.

That advance is already considerable. There is not enough time here to catalog the grievances. Suffice it to say that they include practices which recall the obnoxious test oath, bills of attainder, search and seizure without warrant, Star Chamber prosecutions, and other abuses to the relief of which our Declaration of Independence and Constitution were addressed.

Many of these practices have unfortunately been found to be, as Supreme Court Justice Douglas recently observed: "within the letter of the law. . . . But," says Justice Douglas, "even when lawyers and judges justify them, they violate the ideals of freedom we profess." In formal opinions from the bench, he and other judges have observed that the courts too may be swayed by the tides of emotional majorityism that have swamped the executive and legislative departments.

With great wisdom Alexander Meiklejohn has observed that our constitution provides for a fourth independent branch of the government, co-equal with the executive, legislative, and judicial. This fourth branch in the division of power is the sovereign citizenry, acting in its capacity as the electorate. Clearly, if our system is to work, each elector must be protected from intimidation and coercion, especially with regard to his political action, by public officials who become infected with the insolence of office. That protection is provided by the secrecy of the ballot box and by the right of privacy that shelters the freedom of conscience, speech, and association.

Now, as we have been told so often in the past few years, a citizen has no right to a job on the public payroll. But he is entitled to protection against harrassment and loss of livelihood by executive department loyalty procedures that violate the essence of his constitutional rights. The independence of the elector draws the same clear boundary around the matters that may be legitimately inquired into by legislative committees. Officials and legislators who overstep this boundary are guilty of invading the integrity of the fourth branch of our government and stand in contempt of the electorate.

There is a disturbing tendency for these inquisitorial procedures to spread outside the government into private business, labor unions, and civic organizations. Pressures in this regard are especially heavy upon educational institutions. The president of Harvard, for example, was recently reminded that only a legal fiction insulates privately endowed institutions from supervision by a congressional committee. They could be stripped of their tax exemption for failing to meet some congressional standard in faculty appointments.

In view of the pronounced tendency of this movement to persist and increase in intensity, the following description by Leo Szilard of parallel events in Germany may be taken as a warning of where we might go from here:

> The German learned societies did not raise their voices in protest against these early dismissals. . . . It seemed much more important at that moment to fight for the established rights of those who had tenure, and this could be done much more successfully, so they thought, if they made concessions on minor points. In a sense, the German government kept its word with respect to those who had tenure. It is true that before long most professors who were considered "undesirable" were retired; but they were given pensions adequate for their maintenances. And these pensions were faithfully paid to them until the very day they were put into concentration camps, beyond which time it did not seem practicable to pay them pensions. Later many of these professors were put to death, but this was no longer, strictly speaking, an academic matter with which the learned societies needed to concern themselves.

Fortunately, there are signs of a willingness and a resolve on the part of the academic community to get defensive counteraction going before it is too late. Not all these efforts, however, are wisely conceived. Many betray an utter failure to understand the nature of the challenge. Among them are resolutions and declarations that speak on the topic of civil liberties with great warmth and erudition. But they have a common flaw that vitiates their impact. This is the plea of "Not guilty." The plea is entered, of course, against the charge of Communism. By now it should be clear that no person or institution can be completely cleared of the stigma attaching to this charge. This is because it relates not to acts but to the private realm of conviction and belief.

Besides, this charge tends inevitably to become ever more vague and meaningless. In this condition, it serves even more admirably the purposes of those who use it as a weapon. The less precise

and meaningful it is, the less does it need to be proved and the more impossible does it become to disprove. For the objectives of the demagogue, it must be capable of infinite expansion, ultimately to compromise every position and every conformity except the demagogue's own. The label of Communism has served this purpose well; it embraces not only all shades of Marxism and Socialism but New Dealers, Fair Dealers, and Democrats, and now includes even Republicans.

The real charge here, of course, is not Communism at all, but heresy. This is an imaginary crime in the most literal sense of the term, since it is one that a man is supposed to commit inside his own head. To plead "Not guilty" to such a charge is to permit it to be lodged and thereby to resign the dignity of citizenship that rules such enquiry out of order in the first place. This is the point on which the American Association of University Professors has stood fast since 1915. It is the point that the Association of American Universities regrettably failed to make in its declaration early this year on the problems raised by the self-appointed visiting committees from Congress.

The issue is complicated by the fuzzing out of the legal concept of conspiracy to comprise another new crime—crime by association. Like heresy, this chimera too is dissipated by the clear test of action. It is basic to our sense of justice that a man can be charged only for his own personal acts and cannot be held responsible for the behavior of associates. The charge of guilt by association must be met on the same grounds as that of guilt by thinking: its admissibility as a charge must be denied at the outset.

The charge of heresy is a hoax. But it takes a party of the second part to bring it off. Like the emperor's new clothes, the crime of heresy derives its principal substance from the consent of those who are willing to be hoaxed.

No defense of academic freedom can compromise on this issue of the admission of the crime of heresy to our law and ethics. To do so is to surrender the day to the demagogues and to lend the sanction of scholarship and science to the promotion of fraud. On the contrary, it is what Robert Redfield has called "the dangerous duty of our universities" to defend the heretic and provide sanctuary where heresies may thrive.

It is not only that freedom for somebody else's wrong idea secures my freedom to advance my right idea. Error is essential to the determination of truth itself. Heresy has the same role in scholarly enquiry and in politics as "noise" in communication theory. The theory adapts the powerful thermodynamic concept of entropy, which at its maximum is noise, to permit us to measure information quantitatively on a scale of negative entropy. Warren Weaver sharpens the point by stating that information is thus "a measure of one's freedom of choice when one selects a message. . . . [It] relates not so much to what you *do* say, as to what you *could* say." In the context of a concern with human freedom, this idea takes on a significance transcending its importance in communications engineering. It states, in effect, that what we know depends equally upon knowing what *is* the case and what is *not* the case.

Hence the paradox and the futility of enforced orthodoxy. It is not only that the received view of any subject whatsoever may be in error. It may be in the right. But we can know with assurance only to the extent that we are informed on all the known alternative views. To the degree that alternative views are either not recognized or are suppressed, our information, and hence our capacity for rational thought and action, are reduced. To our peril we expose ourselves to an increased risk of believing and acting mistakenly.

In the end, civil liberties cannot merely be defended. They must be exercised. They have no reality inscribed on fading parchment; they are sustained by no brooding omnipresence in the sky. They exist only to the degree that they are asserted by the action of men. Academic freedom is the most vital area of human freedom because it comprises the frontier. It is not a different kind of freedom, nor a special privilege for a pressure group. It includes and is continuous with the freedom of other citizens. The scholar and the scientist, however, require the widest range of freedom. When they exploit their liberty and advance its boundaries, they enrich and increase the liberty of all.

Here is the connection between the narrowing freedom of American scientists and the condition of our scientific enterprise as a whole. If the objectives of science in America have been subordinated to the demands of technology, this is in part because American scientists have failed to advance to their fellow citizens the case for science in its true role in our culture. Now that the taxpayer has assumed the burden of the financing of science, his well-known enthusiasm for its mere utility must be offset by a deeper understanding of what science is. The people must be shown that science is concerned with the ends as well as with the means of human life; that through increased understanding of himself and the world around him, man may expect to set himself free from the residues of super-

stition and ignorance which still darken his existence; that in the expanding horizons of knowledge he will find motivations and objectives for his actions which are worthy of his natural endowment.

Such an undertaking is essential if the National Science Foundation is not to become a poorhouse for American science, a catch basin for the overflow of design and development projects from other departments of the Federal Government. We may hope that the public education campaign projected for the AAAS at Arden House will be directed to this end and that it will secure the backing of all who have the welfare of science at heart.

The same considerations give added force to the recent statement issued by the Society for Social Responsibility in Science, calling on scientists to "maintain and strengthen the spirit of free enquiry by clear and courageous public expression of considered opinions concerning the relation of science and society." The statement declares: ". . . each person has the individual and moral responsibility to consider the end results of his work as far as he can see them. This is a responsibility to society and implies a strong insistence on public expression of opinion."

Finally, the present situation calls upon scientists to take an unequivocal and unbudging stand on civil liberties. That stand is simple to define: there shall be no compromise whatever with the freedom of the mind. But it is a position that is difficult and dangerous to maintain in practice. It means professors must often be braver than their universities. It means defending persons and ideas that may be obnoxious as well as unpopular. It means individual risk that no man can ask of another. But this is the example of tolerance and courage that distinguishes the contribution of scientists to the history of liberty. It is the example of freedom that our country needs in this hour of danger.

Science for Its Own Sake

V. F. WEISSKOPF

Dr. Weisskopf, a native of Vienna, Austria, and professor of physics at Massachusetts Institute of Technology, was a Fullbright Exchange Professor at the Sorbonne in 1950–51. He served as a research associate at Zurich Institute of Technology from 1934–37, and the following five years he was assistant professor at Rochester University. During 1943–47, he served as a group leader at the Los Alamos Scientific Laboratory.

A DANGEROUS element is creeping into the relations between science and society. It is exemplified by a quotation from a recent newspaper report on an interview with Professor Urey. This report ends with the sentence: "Dr. Urey was awarded the Nobel Prize for ground work in connection with development of the H- and A-bombs."

What was he given the Nobel Prize for? He separated heavy water from ordinary water for the first time and thus produced *heavy hydrogen.* The atomic nucleus of heavy hydrogen is the *deuteron,* which is a proton and a neutron closely bound together by nuclear forces. It is the simplest and most instructive example of the effect of nuclear forces, and its discovery made it possible to study the properties of this new force. This study opened up new ways of understanding and observing the mysteries of the structure of matter. This is what Urey received the prize for, and certainly not for starting the ground work on the H-bomb.

The newspaper remark is characteristic of a general situation. We are surrounded with a public opinion by which scientists are described as secret sorcerers who conjure up bigger and better methods of destruction in closed laboratories. In the more sympathetic moments, scientists are described as cooking up some new chemical with miraculous tricks, which will render gasoline ten times more powerful than before or will improve one brand of tooth paste much above another. Everyone who has had any real contact with science or scientists knows well that this picture of science is highly misleading.

What is science then? May I quote Sir Richard Gregory, the late editor of *Nature*: "Science is one of the great human endeavours to be ranked with art and religion as the guide and expression of man's fearless quests for truth." That sounds somewhat different. But it strikes a strong chord in every scientist's soul. Science is the organized expression of the human trend to penetrate, clarify, and under-

stand the world around us. But it is more. It has a universality and a validity independent of the individual's language in which it is expressed or created. Hence, it has a special human significance. It is a creation of mankind as a whole.

In many ways, science is the most important part of our present-day culture. That might sound preposterous when it comes from the mouth of a scientist, but I will try to give reasons for it. What is culture? It is most difficult to define, but it certainly encompasses the thoughts, activities, and ideals that people value most and are most proud of.

In many respects, the last 300 years of man were not so different from any other 300 years; there were wars, empires rose and fell, literature and masterpieces of art were created. But in one respect this period was different. It saw the development of science. Somehow men found the right approach, and suddenly within only ten or so generations an edifice of human understanding of the mysteries of nature has developed, which has shed light into dark abysses of guesswork and superstition. Of course, this has brought about a mastery of nature as never before. It has led to a longer life span for men and has brought about many other changes which make our planet at present look very different from before. This point has been emphasized many times. What needs more emphasis, however, are the intellectual values, the new insights, the great perspectives, the all-embracing ideas which science has created. Concepts like Darwin's evolutionary theory, in which the development of species can be understood on the basis of causality; concepts like the electromagnetic field, which is the basis of all electric, magnetic, and optical phenomena; the mechanism of genetics, which explains the constancy of the variety in the living world; Einstein's relativity theory; the intricate web of ideas in quantum theory, which gives a fundamental understanding of almost all properties of matter on the basis of electromagnetic forces within the atom. These concepts give us a much more profound view of certain aspects of our world than we ever had before. We quote from a speech of Sir Edward Appleton, whose address before the British Association for the Advancement of Science has inspired the ideas presented here; in fact, this paper is but a poor seconding of his impressive address.

> **So far from reducing life to something cold and mechanical, modern science in its explorations ranges from the heart of the atom to the frontiers of the universe, and, like poetry, reveals depths and mysteries beyond and quite different from the ordinary matter-of-fact world to which we are accustomed.**

These intellectual edifices which men of all countries in the world have built are characteristic of human culture in the last 300 years. They stand out as the Gothic cathedrals did 800 years ago and are symbols of the collective achievements of our century.

How can we try to convey some of this feeling to the nonscientific public? Actually the public is not so far from this point of view as one might think. Why is the science of astronomy so popular among laymen, and from where does astronomy get its large support in this country? Perhaps it is just the aspect of a starry sky on a moonless night that urges everybody to investigate and to find out what it is and how it works, just for the sake of knowledge. The answers to these questions never will give us better bombs or better tooth paste; nevertheless, we build big and expensive telescopes with popular support. This is the true scientific spirit.

It has been said many times that modern science is too complicated, too intricate for the layman; hence he cannot appreciate its cultural values. This argument is disproved by the great demand for popular science books and magazines. The success of magazines like *The Scientific American* or those published by Science News Service proves that the real values of scientific ideas can be transmitted to the educated layman.

Of course, there will be many facets of scientific development that cannot be explained in full to the layman. In our simile of the cathedral, this corresponds to a stained glass window or a statue placed in a high and dark corner and almost invisible to the visitor. However, it belongs to the whole and was put there to the greater glory of God. To use another analogy from the art of music: many fine contrapuntal structures in a symphony are understandable only to the trained musician; nevertheless, symphony concerts are very popular and appreciated by people who do not follow all the intricate structures of each instrumental part.

The English are ahead of us in the task of presenting the true scientific ideas to the public. Their scientists are more concerned with clear and simple presentation than we are. We find many excellent books for the general public written by great English scientists, such as Sir James Jeans, Max Born, Eddington, Julian Huxley, Haldane, and many others. There are not many counterparts in this country.

More collaboration is necessary between scientists and the science reporters of our large newspapers. Educational television is now at the disposition of science. How many of our scientists are thinking about what is the best way to present the great insights and their new discoveries on the television screen? Many too few! It needs much

more effort than heretofore on the part of scientists and educators in order to get science into the correct position which it deserves as the pillar of our contemporary culture. This would help to rectify the present situation, where ample support can be received only when one stresses the importance of science for military security.

Science is more than a way to produce and improve technology. Of course, science and technology are deeply connected, and one is impossible without the help of the other. Recognition of and experimenting with nature's mysteries cannot be kept apart from influencing and controlling them for our benefit. It is all part of the same trend. This trend is one of the strongest and most vital spiritual and intellectual forces of today. It expresses man's search for the essentials and the fundamentals in the world around us.

The Legal Basis for Intellectual Freedom

MARK DE WOLFE HOWE

Mark De Wolfe Howe, who has been professor of law at Harvard University since 1945, received both his A.B. and LL.B. from Harvard. For eight years he was a professor at the University of Buffalo School of Law, serving most of the time as acting dean, later as dean. During World War II, Professor Howe engaged in legal activities for the War Department that earned for him the Legion of Merit and the Distinguished Service Medal awards.

It is not surprising that in this day a gathering of scientists should be concerned with an inquiry into the legal basis for intellectual freedom. Until recently the tradition of free scientific inquiry seemed so secure that it is doubtful whether men of science, by and large, were conscious that the tradition, if not established by law, was at least sustained by legal institutions. In a more tranquil past the scientist saw his freedom not as the fruit of law but as the self-sufficient inheritance of the community of scholars. Perhaps this assumption had come to be more common among scientists than among other intellectuals. Those whose adventures in the world of ideas led them down the pathways of religion or of politics had come to believe that their freedom to inquire and their freedom to believe were secured not only by the attitudes of our civilization and by professional traditions, but by our legal system.

I do not mean to suggest, of course, that the experience of scientists had never led them to appreciate the extent to which their freedom was dependent on law; I merely suggest that there have been relatively few occasions within the period of our national history when the scientific world was compelled to learn the bitter lesson of political experience—to be reminded that the force of government may be applied to control and therefore to condemn the radical adventurer among ideas. We have not forgotten the so-called monkey trial in Tennessee, when law became the instrument of fundamentalism and science the victim of Bryan's bigotry. Such interludes were seen, however, as sporadic comedies rather than sinister portents of an unhappy destiny.

This conception of the scientists, shared by many other intellectuals, that their freedom is not the product of law, has its roots, I believe, in political theory. The philosophical presuppositions of our Bill of Rights have molded our conception of intellectual freedom. We began our national existence in the conviction that there are some phases of an individual's life which are not only beyond the control of government but beyond its reach as well. The area of a man's unchallenged sovereignty was furnished with what the political philosophers called his unalienable rights, among which, of course, was the pursuit of knowledge. The truth or falsity of this presupposition is not our present concern. True or false, it nourished the soil in which intellectual freedom took root in the United States. While it prevailed, the scholar was encouraged in his belief that the community in which he lived his professional life was a self-governing community, and the minister was led to believe that his church possessed

a spiritual authority which could not be impaired by government.

One aspect of this constitutional presupposition deserves particular emphasis. It was accepted in the 18th century, not primarily for the utilitarian purpose of promoting the enterprise of inquiry and thus accelerating the discovery of truth, but for the higher spiritual purpose of securing the individual mind from tyranny. This was among the most important contributions of Christian doctrine to American political theory. What it signified, in so far as law was concerned, was that the individual scholar and the isolated heretic, rather than the enterprise of scholarship or the pursuit of heresy, became the effective instrument of freedom. Our Constitution and our law make no commitments in favor of academic or scientific freedom as such; their guarantee is that the individual's mind—whether that mind be academically, politically, or scientifically inspired—should be beyond the reach of government.

So long as this presupposition prevails in a society, its intellectuals need not fear the penalties that the law of that government stores in its arsenal. If the presupposition is maintained with passion, it will protect not only the thought itself but its expression as well. You need no reminder, however, of the fact that philosophic passion is apt to lose its intensity when brought to the test of political application. It is not surprising, accordingly, that in 1798 our government was willing to allow utilitarian qualifications of Christian principle. By enacting the Alien and Sedition laws the Government authorized the prosecution of those who had vigorously expressed radical political beliefs. Neither the Federalists who first qualified the basic presupposition nor those who subsequently followed their lead explicitly renounced the presupposition. Even today we pay lip service to tradition when, punishing and otherwise disgracing the heretic, we assert that government looks upon the heresy with indifference and only punishes its expression because that expression endangers the nation's security.

Perhaps I acknowledge myself to be a trimmer when I say that in my judgment the qualifications of principle which we have tolerated were virtually inevitable. This is not to say that specific qualifications have been wise; it is merely to assert that no society can be expected to follow inexorably the logic of liberty codified in our Bill of Rights. We have come, I suppose, to assume that the justification for intellectual freedom is not the sanctity of the individual's mind and conscience but the benefits which the enterprising mind and conscience shower on society. If utilitarianism, in its broadest sense, provides the justification for liberty, then the limits on liberty are sure to be set, not by the dogma of spiritual individualism, but by the faltering judgment of each generation as to the character of its needs and the character of the dangers by which it is surrounded. The principle of spiritual individualism if applied with relentless logic would have assured the Mormons immunity from punishment as polygamists as it would assure the Communist immunity from prosecution as one who advocates the forceful overthrow of government. It does not seem to me surprising that we were faithless to philosophic dogma when we allowed the law to penalize the expression of belief.

If what I have suggested has merit, it would indicate that one of the legal foundations of intellectual freedom lies in a philosophic presupposition which we have not entirely repudiated but to which we have not been wholly faithful. Unfortunately one aspect of that tradition, as it affects scientists and scholars, is vigorously alive. Our law still looks upon intellectual freedom as a right of individuals and not as an obligation of groups. When government denies the scholar or the scientist the enjoyment of his right, he stands essentially alone against the state. In any such conflict, particularly when the people's fears support the state, the outcome is readily predictable. The individual succumbs. Since the law's concern was with him as an individual and not with humanity's pursuit of knowledge, it is easy to pretend that any injustice which may have occurred has no larger significance than that of other personal tragedies. The community of scholars will feel that tragedy more intensely than will the body of citizens, but there being no constitutional commitment to the enterprise of scholarship, an appeal to law made in those terms will be unavailing.

So far I have spoken of what the lawyers would call the substantive doctrine of intellectual freedom. I have spoken, in other words, of the dimensions which law ascribes to that freedom. I have, furthermore, suggested that those dimensions have proved unsatisfactory. Our original dogma of spiritual sovereignty was qualified by utilitarian concessions allowing an adjustment between conflicting interests. Yet individualism still controls our doctrine to the extent that law deals only with the rights of the individual and purports to have no concern with the cause which he serves.

These problems of substance have always been with us and have never found, and perhaps never will find, an entirely satisfactory solution. In recent years they have been obscured by another set of problems, novel, fortunately, for Americans, but not unknown to history. These are problems of procedure rather than of substance and affect directly

the whole of our society and not merely its scholars. The world of scholarship today, however, is immediately confronted with these problems and may finally lose its freedom unless they are resolutely faced and courageously answered. The problems of procedure would, of course, have been of no direct concern to scholars had we accepted relentlessly the dogma that the sovereignty of mind is unlimited. For if the individual's mind was entirely beyond the reach of government there would have been no reason to define the processes by which the state could take action against the mind and its activities. Our substantive presupposition, however, has not been maintained with whole-hearted passion, and the state has dealt with belief and its expression. Procedural questions, which have usually concerned few persons except criminals, taxpayers, and businessmen, have now become the concern of teachers and preachers, of scientists and scholars. We have all come to realize that the destiny of freedom may depend as much upon the methods by which it is desecrated as by the objective with which it is attacked.

I have already made a concession which I am sure that some of you consider unfortunate. That was my acknowledgment that the mind of man is not beyond the reach of government and that we must with some fatalism accept the principle that men will be punished for the expression of belief which society considers to be immediately dangerous. Those who join me in that concession will betray the cause of freedom, however, if they take the next easy step in toleration and allow belief to be punished by processes that history condemns and tradition has outlawed. One does not, I think, have to speak in terms of specific constitutional guarantees, such as those against unreasonable searches and seizure, against bills of attainder, against compelling a man to become a witness against himself, to justify the assertion that what legislative committees have done in the last tragic years has been grossly unconstitutional. For our Constitution contains the broader assertion that no person shall be deprived of life, liberty, or property without due process of law. That assertion, I suggest, embodies the basic standard of decency which history has converted into law, and congressional committees have thrown to the winds.

In saying that the standard of due process has become a rule of law which, when enforced, gives sustenance to intellectual freedom, I must be careful, if I am to be honest, not to lead you into false hopes. In its procedural, as in its substantive aspects, the law that relates to freedom makes the individual, rather than the enterprise of inquiry on which he is embarked, the center of its interest. The due process clause protects scholars and teachers, not scholarship and teaching. This means again that the individual attacked by abusive process and punished by degradation rather than imprisonment stands largely alone. He may speak for himself, for his life, his liberty, and his property, for they are secured in constitutional provisions. Yet he cannot speak for the freedom beyond his own, for the liberty of his profession. These, the law will tell him, are not referred to in the Constitution and therefore are not within the orbit of constitutional security.

It is not merely by violation of canons of decency that investigating committees have brought Freedom to her knees. The ingenuity of the investigators has capitalized upon that phase of our legal tradition which denies recognition to the freedom which lies beyond an individual's liberty. The investigators realize that the destiny of that broader freedom is not dependent on the decisions of courts but on the courage of scholars and the fortitude of institutions of learning. The investigators know that if they can spread fear and suspicion among the American people, the courage of scholars and the fortitude of universities will be inadequate safeguards of freedom. The investigators realize that the day may come when the liberty of an individual whom they have degraded and disgraced is given belated recognition by the courts. The investigators are willing to run that risk, knowing that in the meanwhile their effort to subjugate the centers of learning to their will has approached triumphant success.

Some of you doubtless will consider that my charges are exaggerated and that there is no good reason to suppose that the investigators are seeking to destroy the independence of scholars and undermine academic freedom. If you are unconvinced by what I say I suggest that you read the report which the Internal Security Sub-Committee of the Senate Judiciary Committee published last July. There you will see the careful formulation of its program for American education. What it urges is that our schools and colleges should turn to the investigating committees of the states and nation and work in close collaboration with them both for the dismissal of teachers "who have demonstrated their unsuitability to teach" and for the selection of teachers whose inquiries have not led them in unfortunate political directions. The universities will no longer find the security of freedom in law and in self-government but will turn their destinies over to Messrs. Cohn and Schine and their provincial satellites.

If you have followed me thus far I take it that you see my doctrine as infected with fatal despair. I was supposed to tell you of the legal foundations

for intellectual freedom, and I have told you that no such foundations may be discovered, that the best we lawyers can do for you is to tell you to be courageous and remind you that as individuals you have a set of constitutional rights, both substantive and procedural, which in normal times the state is willing to recognize, but which in times of strain it is likely to qualify if not destroy. This is a doctrine of gloom if you expect of law as much as most Americans expect of it.

We will somewhat dissipate the gloom, I believe, and also serve the cause of freedom if we recognize that intellectual liberty must find its strength beyond the law and through other agencies than those of government. Nearly ten years ago Judge Learned Hand, as he always does, gave us the warning of wisdom. "I often wonder," he said, "whether we do not rest our hopes [for the survival of liberty] too much upon constitutions, upon laws, and upon courts. These are false hopes; believe me, these are false hopes. Liberty lies in the hearts of men and women. When it dies there, no constitution, no law, no court can save it; no constitution, no law, no court can even do much to help it."

Sharing Judge Hand's conviction that freedom cannot be attained by law alone, I should like to suggest that there is another instrument than the individual heart which can contribute significantly to the preservation of liberty. If our law does not recognize academic freedom but only teachers, has made no promise to science but only to scientists, has established no religion but merely secured the individual's conscience, there are other authorities within our society whose commitments are broader. I confess that I often fear that those authorities have lost sight of their obligations. Our schools and colleges, even perhaps our churches, have lived in the blandly mistaken assumption that the law is omnicompetent and that intellectual freedom will somehow survive the conflict when the individual scholar goes down in defeat before the state's authority. The universities in my judgment have too frequently overlooked the fact that their commitment is not merely to teachers and tenure but also to the advancement of knowledge and intellectual freedom. In my judgment no organizations other than universities and churches are strong enough to assert against the state that something larger than the fate of individuals is being destroyed by the abuse of power. It is timidity, not wisdom or statesmanship, that converts all problems of freedom into questions of law. Our Bill of Rights is, of course, a code of law, but it bespeaks convictions that lie beyond the law and will only be preserved as a living commitment when the institutions dedicated to freedom, with courage and fortitude, demand the prerogative of freedom and the right of self-government.

Scientists and Political Action

E. C. KEMBLE

Dr. Kemble is professor of physics at Harvard University and a member of the Council of the Federation of American Scientists. During both world wars, he served as an engineering physicist for the Curtiss Motor Corporation.

MY SUBJECT is political action on the part of American scientists. Does it make sense?

Clearly any attempt at political action by scientists as scientists is dangerous business. It could hurt us individually and collectively. The moment we step outside our professional sphere we cease to be experts, and we can act like babes in the wood. Because, to use President's Bronk's phrase, we are by profession "intellectual adventurers," we tend to be nonconformists and politically heterodox. Which of us does not hate and fear international Communism with his whole heart? Yet because we believe in the civil liberties that the Communists most of all deny, we easily acquire the epithet "fellow-traveler," or worse. Moreover, scientists are in an exposed position before the country because in their virtual monopoly of technical secrets of military value their loyalty is important, suspect, and continually subject to the exhaustive inquiries of the FBI and of other investigative branches of the government. This is our situation despite the fact that no other portion of the American public has less in common with the ruthless intellectual, economic, and political tyranny of the Kremlin. These are days in which it is safer for the scientist to keep his political opinions to himself, to join no quasi-political organization that takes a candid view of the Amer-

ican scene. If your friend is accused, have a care before you go to his defense! Perhaps it is best not to stick your neck out.

Just the same, there is another point of view that I am here to defend. It will do us no good to seek refuge in ivory towers if the ivory towers themselves be swept away. Educated citizens in every democracy have a special responsibility, and that goes for us. We still have some influence and we have much to contribute to the solution of many problems facing our country. *It is my thesis, therefore, that American scientists have a clear duty to keep themselves informed about what is going on, and by individual and collective action to make their voices heard.*

We are custodians of a vast social force that is continually changing every aspect of American life. Our country depends on the continued growth of fundamental and applied science for the upkeep of its economic and military potential. We have amongst us knowledge that bears on many special political issues, and a contribution to make to the spirit in which the broadest questions of public policy are approached.

Scientists would indeed be stupid if they were not deeply concerned over the course of public affairs. In point of fact, the interest is there, even though in many cases it shows little on the surface. It flared up strongly after the war, declined, and seems now to be returning. We are all Americans and we all share in the general hopes and fears of this age of crisis. Frustrated by political trends that outrage our deepest instincts, we feel a common urge to raise our voices, to find any possible platform from which to publicize our points of view.

The urge is surely legitimate, whatever its hazards. Whenever scientific understanding is needed for the intelligent formulation of public policy it is the clear duty of scientists to attempt to provide legislators and government administrators with that understanding. In every way acceptable to his fellow citizens, and with due humility, the scientist should join with scholars and educated men of all kinds in seeking to promote the application to public issues of the tentative questioning spirit that we like to associate with scientific research.

So comes the question, "How can the scientist properly seek to implement his sense of social responsibility?" What limitations should he impose on his activities in this direction? Should he act in these matters solely as an individual, or is there a legitimate area for collective action on the part of the scientific fraternity?

The first point to be clarified, however, is the nature of the special issues of concern, those issues on which scientists as scientists can hope for respectful attention. It will, perhaps, suffice here to list some of the more important subjects of this kind in which scientists have actually shown a deep interest since the end of World War II, such a list as one might cull from a casual examination of the tables of contents of the *Bulletin of Atomic Scientists:* (1) the effort to establish a National Science Foundation and give it adequate funds; (2) the drafting of an Atomic Energy Act; (3) the declassification of scientific information and the related problem of the exchange of scientific information with our allies; (4) the problem of loyalty and security, especially as it affects the operation of governmental research laboratories and universities; (5) the problem of visas to permit foreign scientists to visit us in the United States, and the issuance of passports to American scientists for travel abroad; (6) the problem of defense in the case of atomic war and its relation to offensive preparedness; (7) the development of atomic power for nonmilitary purposes; (8) the problem of the international control of atomic weapons; (9) the decision as to the American policy with respect to biological warfare; (10) the decision to press the development of the hydrogen bomb.

In all these special problems scientists have either a direct professional interest or a background of knowledge that gives them a better than average appreciation of the issues involved, or both. Behind such special problems is the unhealthy political atmosphere of the time. Obscuring the real issues, eating its way into our moral and intellectual resources, is the poison of suspicion, hatred, and half-truth that threatens month by month to destroy us. We are like a people sick of a fever that saps daily at our ability to make informed rational judgments. In the over-all struggle to throw off this fever, scientists can play only a minor part. *But we have a special interest in the struggle because the fever attacks everything for which we stand.*

Science does not live by innuendo and the manipulation of newspaper headlines. We believe in the truth and have some idea about how to get at it. We judge the work of our colleagues on the basis of intrinsic merit, not by what we can learn about the political associations of their relatives. We know that the truth cannot always and with ease be expressed in words of one syllable. We know that it is not easy to come by, that it cannot live where there is no freedom of thought, that under the most favorable conditions the best one can do in many cases is to reach a provisional conclusion subject to change as new evidence is available. *We realize that in respect to many important matters the number of*

persons qualified to render informed and objective judgments is tragically small. We realize, for example, how limited is the number qualified by study and experience to guide foreign policy by estimating the effect on other countries of proposed American moves on the chessboard of international politics. We regard the decimation of the small pool of experts in this field on the basis of political prejudice as little short of treachery. It has been said that at one stage in the history of science the wave theory of light came to be accepted because all those scientists who believed in light corpuscles died off. It is *not* part of the record, however, that those who clung to the corpuscular conception died anything but a natural death. The illness of which I speak has destroyed other nations. If it is not to destroy us, every available antibiotic should be marshalled against it.

So much for the problems. Let us now get down to methods. *Individual influence, as I see it, must be primary.* It will be strongest in the case of the most eminent scientists and in the case of project leaders who have direct access to the inner councils of the makers of policy in Washington. I will not bore you with an enumeration of ways in which each of us can make his individual contribution. You will not forget the telegrams to Washington or the letters to the newspapers. *Teachers* can exert an immense long-range influence by spreading the spirit of inquiry, and by the insistence that facts be gathered before judgment is rendered. In this connection I cannot forbear to put in a word for the introductory course in science that treats it as a human enterprise with a long history that has profoundly shaped the way in which we look at ourselves and the world about us. The overtones of such a course can be of high value in spreading the scientific spirit in the community.

But what about collective action? In what ways can we work together on these problems? What kinds of collective action can pay off? Through what agencies can it operate? I suggest first of all the obvious need for joint enterprises in stimulating interest among individual scientists, in supplying them with information, and in helping them to evaluate that information. Here the *Bulletin of Atomic Scientists* has done a wonderful job by maintaining a continuous open forum on the relations between the science and public affairs. It has been ably edited. Its contributors have been distinguished. It is widely quoted and influential. If you want to know how your most thoughtful colleagues size up the urgent problems of science and public policy, you cannot afford to get along without the *Bulletin.* Other publications and other agencies can, of course, assist in the enterprise of mutual education for scientists. THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, through its publications and through such symposia as this, has been most helpful.

A different service for your information and education is maintained by the Federation of American Scientists. This organization of public-spirited scientists has a Washington office and listening post with a permanent staff that keeps a continual watch on developments of concern to scientists in Congress and in administrative policy. It publishes a monthly newsletter and distributes a large number of additional bulletins of information that can be most important when an issue gets hot. The prompt action of the Federation in alerting scientists to the facts regarding the development of the Astin case last spring had much to do, I feel sure, with the satisfactory final outcome of that case.

Information and mutual education—yes. But now comes the 64-dollar question, *Is there a place for the issuance of expressions of collective opinion regarding matters of public policy of special concern to scientists?* The Executive Committee of the Federation of American Scientists does from time to time give expression to its opinions by news releases of this character. So, I understand, does the British Association of Atomic Scientists, which in many ways resembles our American Federation.

Does the issuance of such released opinions serve a useful purpose? Obviously, "Yes." It has the advantage that it receives an attention on the part of reporters, congressmen, administrative officers, and the general public not accorded to individual opinions unless ably expressed by prominent individuals. Such brief released opinions as I have in mind can be formulated much more easily than magazine articles. They reach their destination immediately and can be timely in their effect as magazine articles cannot. Moreover, and this seems to me most important, the hoped-for impact of such released opinions gives to committee members an additional motive for the hours of labor involved in gathering and sifting facts, in threshing out discriminating judgments on which all can agree. I, for one, greatly question whether it would be possible to find able scientists willing to take time to study these problems in detail if the conclusions reached were never to be passed on directly to the public by a news release.

But, of course, there are objections. No doubt some will be raised in the discussion that is to follow this symposium. If the released opinions should be too numerous, or if carelessly or irresponsibly drawn, they would surely defeat their pupose. Moreover, they must meet with the continued approbation of

the membership at large of the organization, a requirement that makes two-way communication between the executive group and the membership a constant necessity. Clearly, too, the activities of such an organization can be of significance to the rank and file of American scientists only *if it gives expression to a common basic orientation on the part of American scientists toward the problems under consideration.*

Of the existence of this common orientation, I am fully persuaded. We do not all vote the same ticket. We do not all place our confidence in the same statesmen and would-be statesmen. But we all share in the scientific spirit. We all believe that public policy should be based on an objective evaluation of all the relevant facts obtainable. We all believe in the leadership of the disinterested and the intelligent, even if we know how difficult it is today to make such leadership effective. We all live by freedom of thought, and we all deeply resent every effort to secure conformity of opinion by coercion. We are a part of the American culture and have our full share in the idealism and generosity that are at the core of the American tradition. Discuss basic political issues with almost any other member of this convention and you will find a broad area of agreement.

To my mind, this area is large enough to justify the *Bulletin of Atomic Scientists* and such an organization as the Federation of American Scientists, however imperfect, in asking for the general support of the scientific community in this country.

Closing Remarks of the Symposium Chairman

At the meeting in Boston the last question from the floor was "What can we do about all these things?" This was in reference to unfair practices in congressional hearings and also in loyalty and security board proceedings. Dr. Condon as chairman responded with the following remarks:

"One of the most important things that any one of us can do is to stand by friends if they get into trouble of this kind and give them every possible support and encouragement.

"We must stand true to the basic American principle that a man is to be regarded as innocent until proved guilty. And in support of this principle, any one who finds himself in trouble should assume that his friends are good Americans who will be true to this principle, and therefore he should not hesitate to call on them for such help and support as they can properly give.

"There are people employed on the staffs of some of the congressional committees, if not members of the committees themselves, who would like to establish the false doctrine that a man or woman should be a social outcast, merely because they have pointed a finger at him or her. Think how easy then would be their job of character assassination!

"Coupled with the equally false doctrine of guilt-by-association, which is being given an ever looser and ever more all-inclusive interpretation, and coupled with a growing tendency to apply such criteria in university and industrial as well as governmental employment, it would then be possible for these committees, acting ostensibly in the name of pure Americanism, to destroy anyone whom they might wish to destroy.

"Therefore I say, remain true to your friends and have faith that your friends, as good Americans, will remain true to you. If all of us do that, the un-American schemes of those who have already done so much to damage American science and American intellectual life will be bound to fail."

Quantum Mechanics and the Aether

P. A. M. DIRAC

Dr. Dirac, Lucasian Professor of Mathematics at Cambridge University, was born in Bristol, England, in 1902. He studied electrical engineering and mathematics at Bristol University and atomic theory at Cambridge University where he received his Ph.D. He was elected a Fellow of the Royal Society of London in 1930, and received the Nobel Prize for Physics in 1933. Dr. Dirac has been a visiting lecturer at the Universities of Wisconsin, Michigan, and Princeton.

THE idea of an aether was a popular one with physicists in the last century. It was a rival to the idea of action at a distance. The latter was never very much liked, because it seems unreasonable for a thing to be able to have a direct effect at a distant place. With the assumption of an aether, some continuous form of matter extending over the whole of space, one can avoid this unreasonableness by supposing each bit of aether to influence only neighboring bits, these in turn influence their neighbors, and so on, thus giving rise to a continuous propagation of physical action.

The aether hypothesis was strengthened when it was found that the laws of electricity and magnetism, as put in their general and exact form by Maxwell, involve only connections between the electric and magnetic forces at neighboring places and give rise to a continuous propagation of electromagnetic effects. The electric and magnetic forces could very well be pictured as strains in the aether.

A difficulty then began to appear, which grew in importance until it finally killed the aether. If the aether is assumed to exist as a real thing, it should have a velocity. The physicist should be able to determine this velocity or, stated more accurately, the velocity of the aether relative to the earth or of the earth relative to the aether. Various experiments were performed for this purpose—the most famous and crucial was the Michelson-Morley experiment—but all experiments gave a zero result. The velocity of the aether would not show itself in any physical effects. The experiments seemed to show that the earth drags the aether with it in its motion around the sun, but this was not in agreement with astronomical observations.

To account for the discrepancy, Lorentz and FitzGerald assumed that motion through the aether causes bodies to change their shape in such a way as to conceal the physical effects of the motion through the aether in experiments like Michelson and Morley's. This assumption seemed a rather artificial one, but it received support from other developments. Lorentz discovered that the laws of electrodynamics do not refer to an aether velocity, they can be formulated mathematically without involving any such velocity, and Lorentz's theory required bodies held together by electromagnetic forces to change their shapes in just this way.

Building up from Lorentz's work, Einstein formulated his powerful *Principle of Relativity*, which requires all the laws of physics to be independent of the aether velocity. According to this principle one should not be surprised at the failure of experiments to measure the aether velocity, but should look upon this failure as a basic feature of nature.

Relativity

Relativity requires one to change the laws of mechanics given by Newton. One must replace them by a new set of laws called relativistic mechanics. The difference is small and unimportant so long as one is dealing with bodies that are moving slowly, but it becomes more and more important as the speeds are increased, and for speeds comparable with the speed of light the new laws are of quite a different character from the old ones.

Relativity, in spite of this revolutionary change which it introduced into well-established scientific ideas, was soon generally accepted by physicists. There are two reasons for this: (a) it is in agreement with experiment, and (b) there is a beautiful mathematical theory underlying it, which gives it a strong emotional appeal. The second reason is

not so much talked about, but in my opinion it is the stronger one.

With all the violent changes to which physical theory is subjected in modern times, there is just one rock which weathers every storm, to which one can always hold fast—the assumption that the fundamental laws of nature correspond to a beautiful mathematical theory. This means a theory based on simple mathematical concepts that fit together in an elegant way, so that one has pleasure in working with it. So when a theoretical physicist has found such a theory, people put great confidence in it. If a discrepancy should turn up between the predictions of such a theory and an experimental result, one's first reaction would be to suspect experimental error, and only after exhaustive experimental checks would one accept the view that the theory needs modification, which would mean that one must look for a theory with a still more beautiful mathematical basis.

To appreciate the beauty of the mathematics underlying relativity one must look upon the world as embedded in a four-dimensional space, with time forming the fourth dimension. The beauty lies in there being a great deal of symmetry between all four dimensions. Certain directions in the four-dimensional space-time are singled out as having special properties, namely, those traced out by rays of light. These directions marked out from a point will form a cone, called the light cone. (To picture these things in one's mind, one should ignore one of the spatial dimensions, so that one has only three dimensions left to think about.)

The main requirement of relativity can be formulated by stating that *all directions within the light cone are equivalent to one another.* Any of these directions can equally well be taken as the direction of the time axis, and there is a simple transformation, the Lorentz transformation, connecting one with another.

Relativity, besides having this attractive mathematical foundation, has stood up well to all experimental tests, so it is now very firmly established.

If there is an aether, its velocity is presumably less than the velocity of light and so fixes a direction in space-time within the light cone. Relativity requires that there cannot be such a direction influencing physical phenomena, so the aether velocity cannot affect physical experiments and therefore can never be observed. A thing that can never be observed is, to the physicist, nonexistent. With the velocity of the aether nonexistent, there can be no aether. By this argument relativity disposes of the aether.

With the abandonment of the aether we do not have to return to action at a distance. We can still have theories in which physical action is local, so that things influence only neighboring things and physical effects are propagated continuously. The only difference is that the things that influence their neighbors must not involve an aether velocity. They must all be able to vanish, to give us the conditions in a perfect vacuum. The aether velocity is excluded because it fixes a direction in space-time, which is a thing that cannot vanish.

It is with such local theories, not involving an aether and conforming to relativity, that physicists have mainly been working during the 20th century.

Quantum Mechanics and Indeterminacy

Another revolutionary change in fundamental physical ideas has been brought about by the quantum theory. The ordinary laws of mechanics do not apply to very small things, such as one deals within the atomic world, as was first shown by Planck. A new mechanics has been built up, based on Planck's work, and in 1925 it received a precise formulation, from Heisenberg and Schrodinger, named quantum mechanics. I cannot go into the details here, but will just discuss one feature of the new theory that we shall need for our future argument, Heisenberg's principle of indeterminacy.

According to this principle, a particle of small mass cannot simultaneously have a precise position and a precise velocity. The more accurately one of these things is fixed, the more uncertain the other becomes, so that the product of the two indeterminacies is always at least equal to Planck's constant divided by the mass of the particle. There is no limit to the accuracy with which a position or a velocity may be measured, but the process of measurement itself introduces the necessary indeterminacy into the other quantity to maintain the principle. The indeterminacy is greater, the lighter the particle. For heavy bodies the indeterminacy is negligible, and that is why we do not notice it in ordinary life.

Quantum mechanics requires this indeterminacy to be fundamental to the nature of light bodies, so that one cannot hope to remove it by experimental refinements or theoretical developments. It causes quantum mechanics to have only a statistical interpretation, so that the result of a calculation is not that a certain event will happen, but that there is a certain probability for a particular event to happen. Statistical results of this kind are all that is needed for comparison with experiment. It is a satisfactory feature of the theory that is does not give more detailed results than could be compared with experiment.

The principle of indeterminacy is, of course, in spite of this good point, just an ugly and rather artificial limitation on our use of the concepts of position and velocity. However, there is a beautiful mathematical theory underlying it, a theory which associates particles with waves and forms the main structure of quantum mechanics. The beauty of this theory, together with the agreement of its results with experiment in a very large number of applications, has caused it to be generally accepted by physicists.

There is some difficulty concerned with the precise significance of indeterminacy, whether it applies to physical reality itself or to our knowledge of physical reality. Einstein has drawn attention to this dilemma. At present no satisfactory answer can be given, as it seems that in the description of various physical processes by quantum mechanics one must adopt sometimes the one view and sometimes the other, according to circumstances. This difficulty does not bother the physicist much, however, because it does not introduce any ambiguity into calculations performed with quantum mechanics or into the interpretation of the results. All that a physicist really wants of his theory is a definite set of rules enabling him to obtain results that can be compared with experiment, and this much quantum mechanics certainly provides.

Example of the Hydrogen Atom

To illustrate the profound changes which quantum mechanics forces into the description of things that are very light, let us discuss a simple example, the hydrogen atom. This consists of a proton and an electron in interaction. We shall ignore the spins of the proton and of the electron, as they are irrelevant for our present discussion.

The proton is a comparatively heavy particle and we can neglect the principle of indeterminacy for it without getting into serious error. It is then permissible to suppose the proton to be at rest at a certain point. The electron will then move about, keeping close to this point.

The electron is a very much lighter particle, and we cannot neglect the principle of indeterminacy for it. This means that we cannot picture the electron as moving in a definite orbit, like a planet around the sun, because it would then have both a definite position and a definite velocity at a particular time. The best we can do is to picture it as a sort of cloud around the proton.

We can talk about the probability of finding the electron at any given place near the proton if we do some experiment of a kind that amounts to looking for where the electron is. This probability would be pictured as the density of the cloud. It is something that the theory enables us to calculate when we are given the physical state of the hydrogen atom. Similarly we can talk about the probability of the electron having a given velocity, or having a given value for a component of its angular momentum or for some other dynamical variable. These probabilities are all things that might be observed by suitable experiments, and can be calculated from the theory.

Now it may be that the cloud is a spherical one, centered on the proton, so that the electron is equally likely to be observed in any direction marked out from the proton. The hydrogen atom is then in a spherically symmetrical state and is to be pictured as round, like a billiard ball. Any experiment performed on it, not involving the spin of the electron or the proton, will give spherically symmetric probabilities for its result.

The most stable state of the hydrogen atom, its normal state, is just such a state. One can disturb the atom and spoil the spherical symmetry, but if one then leaves it alone, it soon jumps back to its normal spherical state. The hydrogen atom is thus like a billiard ball of a kind that is easily knocked out of shape, but which if left alone springs back to its normal round shape.

We are thus led to a surprising conclusion. From the point of view of ordinary mechanics, it would be inconceivable to have a hydrogen atom, composed of a proton with an electron moving round it, in a spherical shape. But it is quite possible with quantum mechanics. The change is brought about by the principle of indeterminacy, coupled with the statistical interpretation of the theory. *It is a general feature of quantum mechanics that it brings in possibilities for symmetry that are inconceivable with ordinary mechanics.*

Quantum Mechanics and Relativity

Quantum mechanics was first built up as a nonrelativistic theory, referring to an absolute time in its basic equations. It had success in accounting for ordinary physical and chemical phenomena. However, great difficulties appeared when it was applied to very rapidly moving particles with speeds comparable to the speed of light.

It was necessary then to fit in quantum mechanics with relativistic mechanics. But it was found that the two kinds of mechanics, each of which had been established in its own domain, did not run together in any very natural way to provide a mechanics for use when the two domains overlap. The source of the trouble is a fundamental one—the basic ideas of quantum mechanics need

an absolute time variable for their mathematical expression, and an absolute time is just what relativity denies.

To get over the difficulty, people built up an extension of quantum mechanics, called quantum field theory, having effectively an infinite number of time variables, which can be made to conform to relativity. This advance was made only at the expense of great complexity in the mathematics and soon led to further difficulties. Particles appear in the theory as points of singularity in fields and give rise to singularities in the equations, which often cause infinities to occur in the results of calculations, so that the calculations do not really give any sensible answers at all.

It is only within the last few years that progress has been made with this problem. Lamb, and following him, Schwinger, Feynman, Dyson, and others have developed a technic for removing the infinities in a reasonable way. The residues which are left can be compared with experiment when they are not too small; and good agreement has been found, namely with the Lamb shift of the hydrogen spectral lines and with the extra magnetic moment of the electron. This is a brilliant confirmation, both of the theory and of the experiments.

However, other aspects of the theory are not so satisfactory. It works only in a limited domain, and attempts to generalize it to get a complete and exact atomic theory have not been successful. The application to mesons has met with no success at all. One is thus led to doubt the validity of the whole structure of quantum field theory with its technic for removing infinities.

Before the discovery of quantum mechanics, Bohr had set up a theory for the orbits of electrons in atoms, which worked very well in simple cases, but failed in more complicated cases. It provided a valuable steppingstone to quantum mechanics, which eventually superseded it.

I think that quantum field theory in its present state should be looked upon as analogous to Bohr's theory. Although it is successful in a limited domain, one may expect to have to alter its foundations before one can can make an important advance. It is only a steppingstone to some future theory which will supersede it.

This view receives strong support from the consideration that the present quantum field theory is complicated and ugly. It has none of the simplicity and beauty which are characteristic of a good physical theory. These qualities occur to a marked extent in relativistic mechanics alone, or in quantum mechanics alone, but disappear with our present methods of combining the two.

The New Idea of the Aether

At this stage we return to the aether. When relativity came we had to reject the aether because of an argument depending on considerations of symmetry. But since quantum mechanics changes the possibilities for symmetry, the question must now be reviewed.

The aether, if it exists, must be a very light and tenuous form of matter, otherwise it would show itself in too obvious a way. Being very light, the aether must be strongly affected by the principle of indeterminacy. We cannot picture a bit of the aether to have a definite position and a definite velocity, as we did the proton in our discussion of the hydrogen atom, but must look upon it as a nebulous thing like the electron. The velocity of the aether will not have a definite value, but will have one or another of various possible values according to a probability law. The previous objection to the aether, that the existence of a definite aether velocity is incompatible with relativity and in disagreement with observation, now loses its force.

At present we do not know enough about the aether to be able to express the uncertainty relations governing it in precise mathematical form, as would be needed to connect the probability law for the aether velocity with the probability law for other physical quantities. Any discussion must therefore be restricted to generalities. One thing we can be sure of is that the velocity of the aether must always be less than (or possibly, in an extreme case, equal to) the velocity of light, as the principle of relativity would not allow any form of matter to move faster than light.

Let us imagine the aether to be in a state for which all values for the velocity of any bit of the aether, less than the velocity of light, are equally probable. In other words, the direction in space time corresponding to the aether velocity must be equally likely to be anywhere within the light cone. Such a state of the aether gives no preference to any direction in space time within the light cone. It introduces a symmetry, like that of the spherical states of the hydrogen atom, which is inconceivable without quantum mechanics.

This state of the aether, combined with the absence of ordinary matter, may well represent the physical conditions which physicists call a perfect vacuum. In this way the existence of an aether can be brought into complete harmony with the principle of relativity.

One point needs further discussion. In ordinary space it is quite evident what is meant by all directions being equally probable. But in the four-dimensional space-time of relativistic theory it is

not evident until one has set up a standard for fixing the size of a neighborhood of directions about a particular direction, corresponding to the solid angle in ordinary space. The mathematics underlying relativity does provide such a standard, but it assigns a very great size to neighborhoods of directions close to the light cone in such a way that the total size of all nonoverlapping neighborhoods of directions within the light cone is infinite. It follows that, if all directions within the light cone are equally probable, the probability of the direction lying in a particular neighborhood is infinitely small. The probability distribution for which a direction is equally likely to be anywhere within the light cone thus does not exist.

We can, however, approximate to such a distribution, and continue to get closer and closer to it without limit. Thus our theory of the aether does not allow the perfect vacuum state to exist, but it allows us to approximate to the perfect vacuum, and to get closer and closer to it without limit.

The unattainability of the perfect vacuum is all that survives of the old conflict between the aether and relativity. There does not seem to be any objection to it on experimental grounds. It will require a considerable alteration in the mathematical methods at present used by physicists working in quantum field theory, where they always start off with the vacuum state and then proceed to study departures from it. They will no longer be able to take the vacuum as the starting point of their theory.

Absolute Time

Having gone so far against the usually assumed requirements of relativity as to accept an aether, we may go a step farther. Before we apply quantization to the aether we may use the aether velocity to establish a definition of local simultaneity. Two points in space time close together are defined to be simultaneous, in an absolute sense, if they are simultaneous with respect to an observer whose velocity is the same as the aether velocity in that neighborhood.

Now it may be that the local simultaneity defined in this way can be integrated to give a well-defined meaning for the simultaneity of two points when they are not close together. This will be true, provided the aether velocities at different points satisfy certain conditions. We can then introduce an absolute time, having the same value for any two points that are simultaneous in this way.

The concepts of absolute simultaneity and absolute time have been condemned by relativity, just as the concept of an aether; but again quantum mechanics saves the situation. After applying quantum mechanics, the principle of indeterminacy will prevent one from saying that one particular point in space time is simultaneous with another, but only that one point has a certain probability of being simultaneous with another. We can again arrange the probability distribution so that the perfect vacuum is a state which treats all directions within the light cone on the same footing, and we again find that the perfect vacuum is unattainable, but can be approached arbitrarily closely.

The principle of indeterminacy smears out the idea of absolute time in the discussion of a given physical state. However, the absolute time remains as a precise mathematical variable, which we may use in the formulation of the dynamical equations of motion. It then brings in great advantages. It restores into relativistic quantum mechanics the inherent simplicity which is such a satisfactory feature of nonrelativistic quantum mechanics and enables us to avoid the great complexities of quantum field theory. Thus the idea of an absolute time is a very attractive one.

In this way the old ideas of aether and absolute time become alive again and can be brought into agreement with all the general physical principles established at the present day.

I would like to emphasize that the foregoing discussion does not prove the existence of an aether or of absolute time. It merely shows that these concepts are not inconsistent with relativity, when one applies them in a setting of quantum mechanics, and so there is no immediate reason for rejecting them. Whether nature has actually made use of them or not is another question.

I do not believe the question can be answered by any general philosophical arguments. The only way to decide it is to make a detailed mathematical investigation and see whether one gets a better description of nature with or without an aether.

Physical theory without an aether has been developed a long way, and has had a great deal of success. It will be necessary to develop an equally comprehensive theory with the aether and achieve an even greater success in order that the existence of the aether may be considered proved.

Because I have spoken so much about the aether, it does not mean that I am necessarily in favor of it. I would be quite willing to give up all idea of the aether if a satisfactory theory could be set up without it. It is only the failure of the world's physicists to find such a theory, after many years of intensive research, that leads me to think that the aetherless basis of physical theory may have reached the end of its capabilities and to see in the aether a new hope for the future.

An Anthropologist Views Technical Assistance

CHARLES J. ERASMUS*

Upon receiving his M.A. degree at the University of California in 1950, the author was sent to Colombia as field representative of the Institute of Social Anthropology, Smithsonian Institution. In Colombia he taught anthropology at the Instituto Etnológico Nacional and during 1951 began studying technical assistance in Latin American countries as part of a collaborative program between the ISA and the Institute of Inter-American Affairs. He was recently a member of the latter agency's U.S. staff in Chile. Mr. Erasmus is a fellow of the American Anthropological Association and the author of a textbook in Spanish on the history of American ethnology.

THIS paper is concerned with conscious attempts to direct or to accelerate culture change, and is based largely on personal observations in several Latin American countries. It does not pertain specifically to the work of any one agency or to technical assistance programs directed only by agencies and governments foreign to the countries concerned. Many if not most of the examples used are drawn from cases where local governments have attempted to introduce change within their own countries. The purpose of the author is to synthesize these observations into a discussion of the patterns of resistance and acceptance demonstrated by the peoples of "underdeveloped" areas in the face of directed attempts to change their ways and to point out the implications of these patterns for the successful and economical operation of technical assistance programs.

Empiricism

Introduced changes that bear clear and immediate proof of their effectiveness and desirability usually achieve a more rapid and widespread acceptance than changes of long-term benefit or changes in which the relationship between the new technic and its purported results is not easily grasped on the basis of casual observation. In agriculture, for example, the introduction of improved plant varieties (higher yielding or more disease-resistant) which result in a greater profit to the farmer has repeatedly resulted in spectacular success stories in many of the Latin American countries, and with a variety of cash crops. A foreign agency in one country developed an improved hybrid corn through local genetic selection. The first year that samples were distributed to farmers, the yield was so much higher than normal that the agency was deluged with requests for seed at the next planting time. In fact, the demand was so great that private enterprise quickly became interested in taking over the job of seed multiplication. In contrast, attempts to introduce soil conservation practices frequently encounter considerable difficulty. Practices that do not bear clear and demonstrable proof of their efficacy in a short period of time usually do not diffuse well on their own, with the result that their diffusion may often be no greater than the range of the agronomist's personal contacts.

The spectacular nature of certain introduced agricultural practices may vary considerably, however, with local environmental conditions. In arid badlands, as those found in some parts of Arizona, for example, where rainfall is confined to one brief season in the form of intense downpours, soil conservation practices may demonstrate remarkable benefits within a very short period. Dobyns shows us how eagerly such practices may be accepted under these conditions, in his case study of a conservation experiment among Papago Indians.[1]

In the tropical lowlands of one Andean country, improved varieties of mosaic-resistant sugar cane have all but replaced the "criollo" varieties since their introduction some ten years ago. The newer varieties demonstrated their usefulness so successfully in the form of higher yields and greater profits that they diffused from one farm to another with a minimum of extension support and promotion. In only two or three small valleys have the older

* The author is indebted to A. W. Patterson, Point Four Director in Chile, at whose suggestion this article was written.

criollo varieties persisted and in these cases because mosaic disease was never a problem, apparently as a result of certain prevailing dry winds. Here the farmers see no advantage to the newer varieties and prefer their criollo in the belief that it is easier to refine.

In public health programs, spectacular curative measures seem to take precedence over preventive ones in the rapidity with which they are accepted. Yaws campaigns carried on by the Institute of Inter-American Affairs, in collaboration with the governments of Colombia and Ecuador, have quickly and successfully overcome the initial resistance of the coastal Negro groups, among which the disease is endemic, and these campaigns are profoundly altering the folk beliefs and the fatalistic attitude formerly surrounding this disease. Even native curers now admit that modern medicine is more effective in the treatment of yaws than their own herbal and magical treatments.[2] On the side of preventive medicine, however, the story in most countries is quite different. For example, the symptoms of intestinal infection in a young child may be diagnosed as "evil eye" by rural populations. In order for these people to be convinced that boiling their polluted drinking water will prevent the symptoms we attribute to intestinal infection, they must be able to observe some measurable decrease in the incidence of the symptoms as a result of the preventive technic. Owing to the conditions under which they live and their failure to understand the reasons behind the new device, intestinal infection may take place through other media, and consequently no relationship between the two is empirically established.

Primitive plumbing. A native *guaduaducto* crosses the highway leading from Medellín to Manizales, Colombia. *Guaduaductos* are flumes made of split *guadua* (large species of bamboo) which are joined together to span great distances between the source of water and the house.

In the case of crops, naturalistic explanations are usually and understandably given to insect plagues while ailments due to microorganisms are sometimes attributed to supernatural causes for which magical preventive measures may be employed. However, when a commercial fungicide, which effectively protects one man's crop against the supernatural maladies that afflict his neighbor's, is introduced into a rural farming area, an empirically measurable relationship is established between the preventive device and the malady. Even though the farmers may not fully accept and understand the modern explanation nor completely abandon their former beliefs, they quickly adopt the fungicide (if they can afford it).

From these examples we begin to see that the people of the so-called underdeveloped areas do not reason very differently from those of areas considered more advanced. Unaccustomed or unable to read, they lack the one great avenue by which more sophisticated populations avail themselves of a broader range of experience (including laboratory and statistical analyses) than would be possible if they were limited to the range of their own casual observations. The reasoning processes of both groups, however, are largely empirical and rest primarily on a frequency interpretation of events. Thus, in the case of a preventive measure for plant diseases or a remedial campaign for an easily distinguishable endemic disease such as yaws, the great number of individual cases plus conditions involving fewer variables permits a frequency interpretation in their favor within the limits of casual observation, whereas conditions involving a preventive measure for intestinal infections in a family of two or three children may not. Therefore, where a new practice can demonstrate its relationship to the improvements in such a fashion that a frequency interpretation is possible within the limits of casual observation, it has a much greater chance for rapid acceptance among the populations of underdeveloped areas.

Very often the nature of an innovation will depend upon proper follow-through by the innovator. In most of Latin America, new technics must be adapted to conditions on which few reliable data are available. Under such circumstances, an unknown factor, which would have been known and allowed for in the United States, will upset the results in such a way that the new practice fails to

United Nations, Point Four, and Ferguson tractor experts explain proper plow adjustments to Chilean farmers. (Photograph by Grover Kincaid.)

make what might have been a spectacular demonstration. In one country, a U.S. technician who was attempting to introduce the practice of broad-base terracing had no data available regarding maximum rainfall and soil conditions to guide him in calculating slope and channel capacity. By diligently checking his first experimental terraces under rainfall conditions, he corrected all errors before any damages might occur. As a result of this careful follow-through and sense of obligation to the farmers, not a single terrace failed when the area was later subjected to a heavy rain of flood proportions. In fact, the erosive action of the storm on adjoining nonterraced fields was such as to make the terracing demonstrations more valuable.

Need

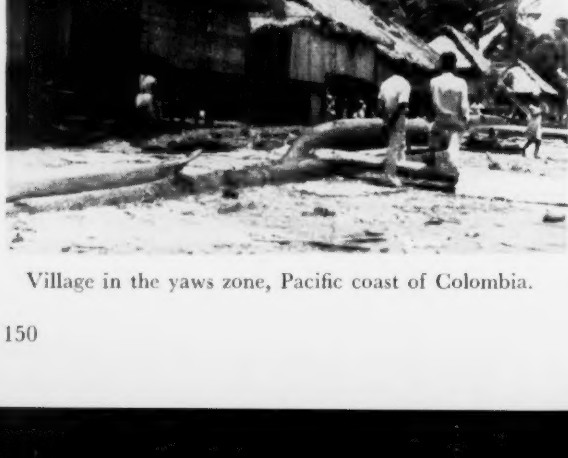
The needs felt by the people, as distinguished from those felt by the innovators, constitute one of the most important factors pertaining to the acceptability of an innovation in any particular case. If the people fail to feel or to recognize the need for an innovation, it may prove impossible to introduce it on a voluntary basis.

Several of these examples, pertaining to the introduction of new agricultural practices, involved not only the factor of their empirical verification at the level of casual observation but also appealed to a profit motive. An improved crop variety, which results in a higher yield or a greater margin of profit, appeals to the profit motivation and the desire for greater purchasing power when the improved variety is a cash crop. When it is not a cash crop, the story may be different. From a study by Apodaca of the introduction of hybrid corn into a community of Spanish American farmers in New Mexico, we can see how motives other than those of greater profit may affect the outcome when the crop to be improved is not being grown for market.[3] Within two years after the introduction of the hybrid, three-fourths of the community had adopted it. But after four years, all but three farmers had reverted to planting their original variety. The hybrid had doubled production per acre; the farmers had met with no technical difficulties in planting it, and the seed were readily obtainable. However, the corn was raised by the community only for its own consumption. As these people eat their corn largely in the form of tortillas (unleavened corn cakes), an important mainstay in their diet, and since the new hybrid did not yield tortillas of the same color, texture, and taste as their own corn, they reverted to their older variety. These reasons were more important to them than was the quantity produced. Apodaca notes the fact, however, that the hybrid was dropped with considerable reluctance by the farmers because of its much greater yield. They had empirically verified the fact that the hybrid

was an improvement over the old in one sense, but not in the prime sense which pertained to their particular needs and values. This illustrates what can happen when an improvement that would normally have high appeal under cash-cropping conditions is introduced into a subsistence-oriented cropping pattern.

Let us now turn to examples where subsistence-oriented agricultural improvements are introduced into a cash economy situation. Several years ago the ministry of agriculture in a South American republic sponsored a program to introduce the planting of soybeans in many rural areas. Today, the only place where this crop is planted on any scale is near a city where it is manufactured into vegetable oil. The object of this program was to induce the rural population to improve their diet. Soybeans, considered more nutritious, were to be produced solely for family consumption. The farmers not only found the new food distasteful but discovered that no one cared to buy it, and the movement quickly collapsed. In this case the appeal was made to a better health rather than a greater profit motive, but for the farmers the improvement was not empirically verifiable. Symptoms of malnutrition are often confused or combined with symptoms having other etiologies according to modern classifications of disease and are ascribed to supernatural and other causes which bear little or no resemblance to the medical explanations of the innovators. Therefore, in such cases no feeling of need for a new practice may arise to offset the disagreeableness of changing long-established food habits.

In numerous countries attempts have been made to induce rural populations to cultivate vegetable gardens for home consumption. In all cases observed this, too, usually fails after the program has terminated, if the farmer has found no market for



Village in the yaws zone, Pacific coast of Colombia.

the new product in the meantime. Vegetable crops generally enter an area close to cities and towns, or along reliable communication routes leading to them, where the market is greater. Once farmers grow vegetable crops for profit, they invariably consume some. In one Latin American mestizo community where a health program had enjoyed some degree of success in introducing family vegetable gardens, several farmers said that the best way to pacify government programs was to go along with them and do as one was told; eventually the program would terminate, and then they would abandon the nuisance of vegetable gardens without creating any disturbance.

In another Latin American republic, a government-sponsored agency, designed to look after the welfare of farmers growing a cash export crop of importance to the national economy, instituted a program of aiding farmers to build new homes and improve farm structures that were necessary for properly processing the crop. The agency found that it received many more requests for the processing structures than for the homes, although the cost of both types of units was being borne largely by the agency. The farmers were required to pay a small percentage of the total construction costs, and a majority of them preferred to invest in the labor-saving devices. Frequently the field men of the program scolded the farmers for thinking only of their own convenience and never of the cramped and unsanitary quarters of their families. Again we find an example where the needs felt by the people were not entirely in accord with those felt by the innovators. Farmers accustomed to living under housing conditions which the innovators considered undesirable did not necessarily share this view. The processing structures, however, were already known to the farmers who were aware of their labor-saving advantages. The theory underlying the housing program was that more sanitary living conditions would result in more able-bodied farmers and in higher production. But a majority of the new houses rapidly returned to the same state as those they had replaced, a further indication that the needs felt by the innovators were not generally perceived by the farmers. New houses built on farms located along main highways or near population centers showed better maintenance than those that had to be reached by mule-back. Apparently, greater contact with external influences and the cultural environment of the innovators created a sense of need similar to that felt by the innovators.

Let us turn next to an instance of rapid change independent of any superimposed direction. Near two large cities along a semitropical coast, dairy

farming recently has come into greater prominence because of the increasing market for milk. Large and poorly managed haciendas, formerly devoted to the pasturing of beef cattle, are breaking up into smaller and more efficiently operated dairy farms. The dairy farmers on their own initiative have imported improved dairy strains and have adopted improved feeding practices and silage. Some farmers have learned to keep daily records of the milk production of each cow, and on the basis of these records to practice selective breeding of their best producers. These dairymen are sensitive to new technics and knowledge. The local economy already has created an urgent need for new ideas, with the added promise of a high degree of acceptance. Diffusion of ideas from the most advanced to the least advanced farms is proceeding at a rapid rate.

We can see that when the objective of technical assistance is to increase production in an underdeveloped area, it is easier to realize among people who participate in a cash economy. Rural people who are cash-cropping for national or international markets frequently tend to specialize. More attention is usually given to a particular crop, such as coffee, sugar cane, wheat, or potatoes. The local group often forfeits a great deal of its self-sufficiency in the process of specialization and consequently grows more accustomed to purchasing specialized products of other areas. An increasing tendency to purchase products external to the area is in turn usually accompanied by an increase in the number of new products and ideas entering the area, and the number of new needs thereby created. This type of situation seems to be more conducive and sensitive to change. Needs created by the process of specialization and the desire for increased production and profit actually seem the easiest for technicians from another culture or subculture to meet. The solution is often largely technical, fewer cultural barriers to a common understanding are presented, and the perception and feeling of needs are more easily shared by the innovators and the people.

However, when change is being attempted in a field not directly related to increased production in a cash economy, in other words not directly in terms of profits, the difficulties increase. In the field of public health, for example, the innovator may consider it highly desirable to introduce basic disease prevention measures into an underdeveloped area. But the folk still subscribed to an age-old system of beliefs about the cause, prevention, and treatment of disease, a system so different that the preventive measures of the innovator were mean-

Yaws victim, Esmeraldas, Ecuador. School attendance of Negro children has nearly doubled in many places along the northern coast of Ecuador as a result of Point Four campaign to eradicate this crippling disease. (Photograph courtesy Servicio Cooperativo Interamericano de Salud Pública, Ecuador.)

ingless. Lacking an understanding of the modern concepts of the etiology of disease and consequently the reasons for modern methods of prevention, they may feel no need to adopt the prescribed changes. Thus, despite the fact that they feel a general need for assistance in combatting the ailments common among them, they may fail to perceive the need for the specific measures proposed and may actively resist them.

Cooperation

Until now this paper has purposely been limited to examples of changes whose acceptance and diffusion are largely an individual matter. As has been seen in the case of spectacular innovations such as improved plant varieties, this type of change frequently spreads with phenomenal rapidity from one individual to another with very little outside stimulus. However, some changes may require group or community adoption, a circumstance that can greatly increase the operational difficulties of introducing them. Not only must the need for the change or changes be perceived by the entire group

or a large majority simultaneously, but the members of the group must cooperate for the given end.

Holmberg provides us with an excellent example of an assistance project which depended upon collective acceptance and which failed even though it was concerned with a need already felt by the people.[4] In a community in the Viru Valley of Peru, villagers had petitioned the Peruvian government for aid in obtaining well water to supplement their river supply during periods of shortage in the dry season. A permanent and reliable water supply was important to these people for household and for irrigation and production needs. Although a well was successfully dug, the entire project failed because the technicians did not consult with leaders of local opinion or seek to involve the people. Antagonisms based on local social and political conditions became so great that it was necessary to withdraw the project.

Throughout one Andean country an attempt was made to establish farmer committees, by means of which it was planned to bring about agricultural improvements. In only one small mountain sector did the movement have success, and here only among farmers who until a few years before had been living in indigenous communities. Accustomed to a measure of independent local government in the past, they were organized with very little effort. Obviously, then, the failure of this program must have been due in part to the organizing technics, for the few successful cases were the result of highly favorable local circumstances.

It would seem that in many parts of Latin America there is a tendency to consider rural populations as more cooperative than they really are, or at least to take their cooperation for granted. However, in Latin America today many of the age-old customs promoting cohesion and cooperation in rural society are being or have been replaced by social relationships of a more impersonal and individualistic nature. Such replaced customs would include the mutual aid and assistance patterns involved, for example, in reciprocal farm labor and the ceremonial kinship obligations of godparenthood. Apparently the economic aspects of such mutual assistance customs were functional in a subsistence-oriented rural economy, where the peasants cropped largely for family and local consumption. As roads increased the possibilities of marketing farm surpluses over larger areas, farmers began to specialize and came to be more dependent on other regions and countries for marketing their products and for the food and goods no longer produced on their own farms. Thus, the interdependencies existing between members of the local group in daily contact were gradually superseded by national and international interdependencies between peoples who never met. When the economic interdependencies between members of the local group were superseded by larger and more impersonal ones, the cooperative functions of older customs were unnecessary. The rural peasantry became more individualistic and less dependent on their daily contacts.

Actually, it may be fairly argued that the rural populations of Latin America are becoming more competitive than collective. Perhaps one of the clearest illustrations of this may be found in 4-H club work. Results are usually better when the young people work separate plots in competition than when they work the same land together in such a way that they cannot compare their work. Similarly, when earnings of club members are pooled for the purchase of livestock or tools used in common, the results are usually poorer than when each individual has the right to the fruits of his own labor. In such instances we can see how the profit motive coincides with individualistic and competitive tendencies.

When a technical assistance project in a certain country attempted to contour level rice fields across ownership boundaries in order to facilitate irrigation flooding in a pilot area, it was faced with the problem of obtaining the permission and collaboration of all the small landowners within the area. However, the technicians neglected to unite the various landowners concerned, to explain the project to them, and to seek their cooperative support. The project was carried out as if it were a type of change which could be effected on an individual or family basis. One farmer was induced to permit the contouring, then another, and so on. Because of the severe land fragmentation problem, the owners of neighboring plots were not necessarily neighbors in so far as the residence patterns were concerned. Even when a farmer and several of the friends who lived near him were convinced of the benefits of contouring, their plots within the area were found to be widely separated. As planting time approached, the project officials felt obliged to rush the job through, and so began contouring the individual and widely separated plots as functionally separate units. As the work progressed, other landowners began signing up. Eventually, nearly all gave permission to contour their land and agreed to pay the costs. But the sequence of requests was such that practically all contouring had to be done within, rather than across, ownership boundaries. Inasmuch as nearly all the farmers eventually collaborated, there is reason to believe that with the proper in-

Point Four technician Grover Kincaid prepares a model soil conservation exhibit for a rural fair in Chile. Photograph by Monta Wing.)

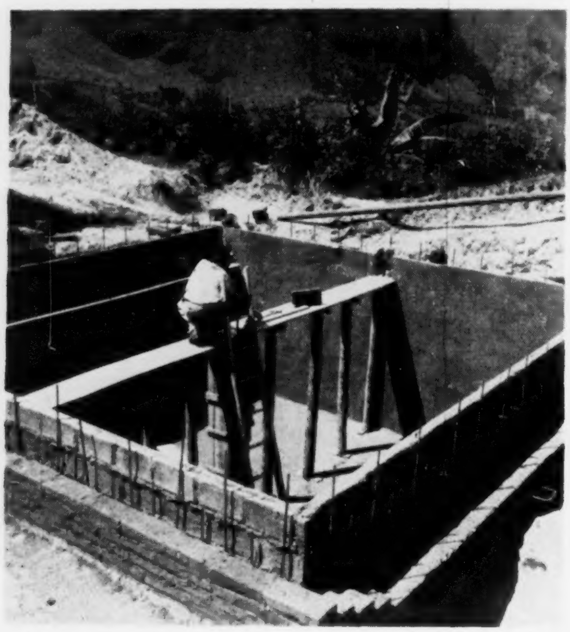
ducement they could have been encouraged to do so before the work began. As a result, one of the major objectives of the project, to contour according to the topography rather than ownership boundaries, was lost.

Inducement

The problem of inducement, as we shall use the word here, refers to the task of overcoming popular resistance to a proposed change for any of the reasons discussed so far. Even in the case of new technics or traits which demonstrate their effectiveness in a spectacular fashion, there is still the initial problem of bringing them to the attention of the public. If the problem is one of introducing an improved plant variety, some farmer or farmers must be persuaded to try it. If these initial experiments result in a much greater yield, the new variety usually sells itself. Generally, farmers are suspicious of government authorities and prefer to let someone else try the new technic before they adopt it. If a well-known neighbor obtains satisfactory results, others will often rush to follow his example. Demonstration farms are not so readily copied, as the farmers are not sure what additional advantages beyond their own means may have biased the results. When a large brewery in a certain country found that the home production of barley was insufficient to supply its needs, it hired agronomists to stimulate production in new areas. The agronomists circulated through the highland regions, promised farmers a good price for barley, gave instructions for planting, and provided seed. The first year very few farmers in a given area tried the new plant on a very modest scale. However, by the third or fourth year, after all had been convinced that the agronomist would keep his word about the price and that the plant would give profitable yields, barley had become one of the important crops.

Where the advantages of a new technic or trait are long term in nature or difficult to demonstrate empirically, long-term methods of introduction through formal education should seriously be considered. Extension work with adolescents through 4-H clubs and the like frequently demonstrates that it is easier to instill new habits among individuals who do not have to unlearn old habits. Furthermore, young people usually find it easier to substitute the prestige of the specialist for the prestige of tradition.[5] Even when introducing nonspectacular innovations on a long-term basis through formal educational procedures, it will usually be necessary to take popular beliefs and practices into account so that persons may perceive a relationship between the needs they feel and the remedies proposed. In

Quito, Ecuador, tests were given to school children who had been receiving formal lectures in health education, including the use of visual aid technics for some two years. Results showed that the period of instruction had made little or no impression. Whereas modern explanations of the etiology of disease and its prevention were now familiar to the children, they were largely related to modern disease terminologies that had no meaning to them. The symptoms of those diseases were still being classified according to a folk system which included such causes as fright, evil eye, malevolent air, and witchcraft. According to the school children, these folk illnesses could not be caused by modern etiologies, could not be prevented by modern means, and could not be cured by medical doctors. In collaboration with the educators, attempted changes in the methods of instruction were made so as to allow the children to discuss their folk beliefs freely in class. During the discussions the educators attempted to show the children, without deriding their beliefs, that the symptoms they ascribed to fright, evil eye, and the like were the symptoms of the very diseases that the educators had been talking about for the past two years. They also tried to disassociate folk symptoms from folk etiologies and practices and to link them to modern methods of treatment and prevention. Retesting after the lectures gave very different results. Written tests, of course, do not necessarily indicate a change of habits, but these certainly indicated that for the first time the children were cognizant of a relationship between the measures and explanations of the educators and their own maladies. This illustrates the necessity of thoroughly understanding the local culture of a people, in cases where it is difficult for them to perceive the needs felt by the technicians under the ordinary limitations of casual empiricism. Ironically enough, salesmen for patent medicine concerns frequently give very careful consideration to folk beliefs in order to adapt the advertising of their products to the local concepts of disease.



This new reservoir will supply some 250 Colombian farmhouses with running water and will replace several *guaduaductos.*

In some cases people can be induced to accept new technics and changes, which they find difficult to accept, by linking them or making them conditional to other changes or services more desirable to them. For example, in anticipation of an irrigation project that they know will materially benefit them, farmers may be more willing to satisfy government wishes concerning secondary improvements which they would ordinarily resist. In the example of the contour leveling of rice fields, it seems very possible that one of the principal mistakes of the program was in failing to obtain commitments by the farmers for the leveling before the irrigation project was completed. As the farmers had already been provided with irrigation water, the inducement value of the irrigation project had been lost.

Similarly, where public health centers give attention to curative as well as preventive measures, their rapport with the public as well as their influence in implementing changes in disease prevention habits is noticeably greater. At a charity maternity hospital in Quito, those new practices, in conflict with popular beliefs but with which mothers had to conform in order to receive treatment at the hospital, were found to be having an important and permanent influence in altering their beliefs. In agriculture, the distribution of seeds and tools at cost may offer a decisive inducement to adopt recommended new cultivation practices. Where farmers can see no need for a program objective, it may be possible to alter the emphasis of the objective so as to enhance its appeal. In one Haitian valley, agronomists were able to effect measures of soil conservation by appealing to a local interest in coffee planting and by helping the farmers to start seed beds of coffee and shade trees for transplanting to hillside plots.

Where joint and cooperative action on the part of a community is necessary for the success of a project, considerable attention must be given to involving the people in the activity at an early stage. The leaders of opinion in the community must be discovered and consulted first. Whenever possible, the

community should be made to feel that it has participated in the planning of the program. When cooperative programs are simply dropped upon the peoples of underdeveloped areas from some high planning echelon within their government, without any explanation and without any consideration for local opinions, the programs are very likely to fail either partially or totally.

In any technical assistance program one of the most important and most variable aspects of the problem of inducement involves the factor of person to person relationships. Much has been expounded on this subject, but the desideratum usually consists of little more than a consideration for the beliefs and customs of other peoples and a sincere attempt to understand them. Yet understanding can be no greater than allowed by the amount of personal contact and the ability to communicate.

A most effective foreign technician was a U.S. soils scientist attached to an agricultural research station in an Andean country. Good-natured and affable, he set out at once to make a friend of every member of the staff. Within his special field he led the local technicians to adopt several new research procedures, and saw several research projects of considerable importance well under way. Yet he never allowed his name to be attached to any project. He encouraged the local man most interested in the plan to initiate it, carry it through, and take the credit, while he played the part of a counsellor who continued to make suggestions but never gave an order. Three nights a week on his own time he held classes in English because he had discovered that many local technicians wanted to learn the language and that he made friends by helping them.

Complexity

Frequently a change which seems desirable to the innovator may depend upon so many other secondary accompanying changes that its introduction is difficult. Perishable food products, such as fresh vegetables and fish, are most easily exploited near markets where transportation to markets is reliable, inexpensive, and rapid, or where storage and processing facilities have been developed. Successful adoption of improved livestock may depend upon many correlative changes in husbandry practices. The latter in turn may depend upon the farmer's financial ability to provide better feed and care.

Failure to recognize the factor of complexity is one of the most serious problems in technical assistance work, partly because there are no established principles of diagnosis which can be applied to every case. Oftentimes the standard of living may be so low that the innovator's heart goes out to the evidences of suffering which seems unnecessary to him from his different cultural or subcultural viewpoint. Let us take for example country "X," whose density of population and infant mortality rate are among the highest in the world and whose per capita production is among the lowest. Is the first job of technical assistance to save lives and reduce the immediate evidences of human suffering, or is it to help the country itself to solve its health problems? The answer to this question depends on who provides the funds to build the public health centers, the water purification systems, and the public hospitals, and to educate the doctors and nurses. If the innovators provide these funds, the effort may involve much more than technical assistance; it may involve heavy financial assistance. As a result the population may increase more rapidly than ever, and with it all the existing economic and political stresses may be aggravated. However, if the innovators are concentrating on purely technical assistance, they may endeavor to help country "X" raise per capita production to a point where the country can pay for its own secondary improvements as it feels the need for them. In short, this would mean that technical assistance in country "X" might be aimed first at increasing productivity in agriculture and industry, while assigning the high infant mortality rate to a secondary position on its list of problems.

This extreme case is used simply as an example and does not mean that technical assistance in public health should be relegated to a secondary position in all countries desiring technical aid. In some countries productivity per capita is much higher than in others and public health services for the population are already well established. In such cases, technical assistance for making these services more efficient is readily grasped and utilized and effects of the technical assistance are far more permanent and far reaching. U.S. public health technicians in one small country have played an important role in a malaria campaign to clean up a wide coastal zone that was formerly poorly exploited. Roads are now being cut through the jungles, exploitation of forest products is intensifying, and new settlers are entering the area to establish banana and other plantations. Thus an entire nation has been benefited by these public health workers.

A price-support program for cotton was adopted in one country in order to induce greater home production for local textile industries. Within a period of three years agricultural changes in some areas have been almost revolutionary. On flat coastal plains to the east, land that was formerly

yielding a very low rate of income per acre from an extensive type of beef-cattle ranching is rapidly changing into a zone of mechanized agriculture. Cotton has become white gold. Not only have many farmers rushed to exploit the new opportunities with mechanized farm equipment, but they have adopted new farming technics such as the use of fertilizers, insecticides, and crop dusting. This example is not used to justify price-support programs, but it does show how increased profits facilitate the adoption of new practices. They do not make such change automatic, however, for the same factors of need and empiricism still apply. Many farmers started planting cotton without heeding advice to use insecticides. They suffered serious crop damages the first year and saw the difference between their yields and those where insecticides were used, and then they adopted the practice the second year. Nor did cotton planting itself become generally adopted until a few enterprising farmers had made a handsome profit.

In situations of extreme land fragmentation where farmers must supplement their agricultural earnings by means of other endeavors, it is usually extremely difficult to initiate changes in farming practices. A higher yielding plant variety may be readily adopted, but many other innovations are difficult to introduce on uneconomical farm units. However, a desire to help impoverished farmers may lead administrators and technicians to attempt the introduction of improvements of a subsistence nature which require little or no capital expenditure. Programs may thereby develop with the purpose of introducing the household manufacture of family clothes, home gardening of all food necessities, home food-preservation practices, and inexpensive animal varieties such as rabbits as a source of meat for the family. All such devices are aimed at making farm families more self-sufficient and less specialized, a process contrary to the usual economic trends. Social welfare programs of this type seem to require more extension personnel and promotional activity than those designed to bring production-increasing technics to farmers who have the finanical means to exploit them.

In one South American country where soil erosion has become extremely severe, U.S. soil conservation experts found that practically no remedial steps were being taken. In some areas, erosion had reached a point where only such drastic measures as complete reforestation would suffice. In others, the erosion problem was complicated by absentee land-ownership patterns or the exploitation of uneconomical farm units. However, by selecting an area of medium-sized mechanized farms personally administered by resident owners, the technicians were very successful in introducing many new soil conservation practices with a minimum of promotional activity. Farmers responded readily, were quick to recognize the benefits of the new measures, and found them easy to carry out at their level of operations. As a result of the impetus given to soil conservation by the successes in this area, the government created a special soil conservation division, within its ministry of agriculture, to attend to the erosion problems of the country as a whole.

In one sense, the areas of worst erosion in a country might be thought of as presenting the greatest need for correction, or the poorest farmers as the ones most in need of improved agricultural practices. Frequently, however, the persons most in need, in the judgment of the innovator, may be those who feel the need the least. For this reason it may often be more expedient and practical to work where the need, from the innovator's standpoint, is less acute but where there is greater willingness on the part of the people to make the change. The interest shown by the people themselves is more often a better index to their ability to successfully adopt a given change than the judgment of the innovator.

Economic Feasibility

Any technical assistance project will cost money, the expense of this assistance being in proportion to the number of man-hours necessary to complete it successfully. It would be quite logical to suppose that, given unlimited financial and human resources, a technical assistance program could effect any change desired. However, no technical assistance project has such unlimited funds; therefore, in any decision concerning the selection of projects, their feasibility with respect to budgetary limitations must be taken into account.

From observations of technical assistance projects, the kinds of innovations which would seem to be most inexpensive are those which require the least man-hours for strictly promotional purposes. Such innovations include those from which benefits are easily verifiable through casual observation, which are accepted and diffused on an individual basis, which meet a strong need already felt by the people (of particular appeal to a profit motive), and those which are in sequence with local development (not too complex). However, certain circumstances may justify considerable promotional activity. For example, in the case of projects requiring cooperative acceptance and action on the part of the people, the necessary groundwork must be done

to involve them in the activities, or the time and money spent in the purely technological aspects may be lost. In such cases the two deciding factors are the amount of money being invested in the technological aspects, and the need which the people feel. In the case of an expensive irrigation project, about which the people are highly enthusiastic and for which their cooperation is requisite, the extension work necessary to iron out local social and operational problems for the maximum success of the project should be considered a functional requirement. However, where considerable money is to be spent on a project in which the cooperation of the people is essential but for which they do not even feel a need, the project should be reexamined to see if it fits into the local sequence of development. If a project is very inexpensive but would require costly promotional work to secure the necessary cooperation from the people, the project should be reexamined to see if the ends really justify the means. It frequently happens, for example, that innovators like to initiate projects which require cooperative action from the people because they consider the encouraging of cooperation and community spirit as good and worthy projects in themselves.

The principal consideration in questions of economic feasibility is that of the needs felt by the people. When the people do not feel a need for the innovations proposed, promotional activity necessarily must be increased. Fortunately, actual situations are usually neither all negative nor all positive; differences exist in degree, and some persons within the same group or area are more receptive than others. In the case of soil conservation, for example, some farmers with better farm equipment, more capital, and a long-term outlook can be shown the benefits of soil conservation with relatively little difficulty, while neighbors with more modest resources continue to take a skeptical view. However, when a nucleus for change can be permanently established, even though the prospects of diffusing the change outside that nucleus in the immediate future are poor, the long-term gains may justify the modest beginning. Eventually others may come to recognize the benefits of an innovation at a time when conditions make it easier for them to adopt it or to appreciate its advantages. Thus, rather than spend time and money to promote the adoption of an innovation among people who cannot perceive its desirability, it may prove more expedient to establish it among strategically located nuclei or groups who can.

Another long-term alternative to costly promotional activity to establish a sense of need for new

Two-year-old home constructed by a rural housing program. Plumbing and cement-paved kitchen are no longer in use. Family has added old style adobe kitchen with dirt floor and smokehole in roof to back of new house. Sanitary conditions are now the same as those in the family's previous dwelling.

measures is that, already mentioned, of appealing to the younger members of the society through existing educational institutions. A few strategic lectures to groups of teachers, as well as assistance to them in the form of educational aids and printed matter, can often have a widespread, long-term effect.

The most unfavorable conditions for introducing innovations are frequently presented by such marginal peoples as Indian groups who more than anything else may simply wish to be left alone. The effort involved in introducing changes among them will be particularly great when their economy is still subsistence-oriented. Their conception of needs may be so different from that of the innovators that the two groups may find it very difficult to establish a common meeting ground for mutual understanding.

In general, the absorption of marginal peoples and cultures into the national sphere seems to follow most rapidly upon their further involvement in the national cash economy. In many cases it may prove more expedient to develop areas bordering on marginal groups in such a way as to draw them more closely into the national economy than to attempt to superimpose an extraneous need system directly upon them. While living in a Mayo Indian *comunidad* in southern Sonora, Mexico, during 1948, the writer had an opportunity to note the effects produced on an indigenous community by

the rapid development of bordering areas. The development of irrigation and a more intensive machine agriculture to the north was creating more job opportunities and prosperity. Not only were members of the *comunidad* going north more frequently to work as seasonal agricultural labor, but they were returning with new ideas, needs, and wants. In fact, a growing nucleus was advocating division of the communal land as a means by which wealthy farmers could gain access to much of the virgin land and extend irrigation into the area. Thus it was hoped that a more intensive and profitable type of agriculture would be possible for all.

A similar situation was encountered at the plantation of an American fruit company in a Latin American republic. The manager of the plantation told how the labor turnover the first year or two was over 90 percent. Individuals worked until pay day and then went on a drinking spree, or worked only until they had earned enough to buy something they had specifically wanted. However, as new laborers kept replacing the old, some of them would inevitably join the nucleus of steady workers. These valued the permanent income, the clean and comfortable company housing, the superior company school for their children, and the company medical treatment. Within a few years the plantation had a permanent resident labor force. The company showed an interest in the upkeep and attractiveness of the workers' housing and helped them landscape gardens around their homes; thus a model community had been formed that was influencing the entire area. Workers in neighboring locally managed plantations were beginning to demand the same treatment, as they perceived a need for it themselves.

Not everyone can be induced to share the values and needs of the innovators at once but, by working first with those who already share them, the changes may eventually have far-reaching results without the unnecessary expense of promotional methods. In short, action programs among those who already feel a need for an innovation would seem to be more effective and less expensive in the long run than promotional programs for those who must first be inspired to feel the need.

One of the greatest weaknesses in most technical assistance programs is the failure to recognize the indispensable part played by research in increasing their economic feasibility. In this respect, government might conceivably learn from business. One writer on the subject of business management has said that any company that lacks an organized program of research will eventually find itself out of business.[6] Two major forms of business research, market and engineering studies, might be paralleled by technical assistance agencies to their advantage. Market studies could be designed to get all the pertinent facts about the people to be changed, including their needs and wants, their ability to absorb a given innovation, and their previous reactions to similar programs in the past. Engineering studies might include research in any number of technical fields, as well as comparative research in the methods and results of other agencies in other parts of the world, and the continued self-evaluation by the agency of its own programs to perfect the least expensive and most effective means of realizing its objectives. However, in government assistance programs, research can probably be realized best through an organization pattern that recognizes the difference between staff and line functions. Government reporting is prone to be a line function originating with operations personnel, who execute it with a bias toward justifying the further existence of their programs. By avoiding the disclosure of mistakes in specific operations, short-term benefits may accrue which on a long-term basis prevent the self-evaluation and self-correction necessary to avoid those seriously damaging setbacks that result from the accumulation of hidden errors.

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The Place of Anthropology in a Technical Assistance Program*

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THE Technical Cooperation Administration, popularly known as Point Four, has launched programs in a large number of so-called backward countries. The basic purpose of this type of activity is to provide technical assistance to these countries, to improve agriculture, education, economic conditions, and health. This is, in effect, to attempt intentional cultural change, starting from a definite set of conditions and moving toward a definite goal. The failure to recognize the nature of this intended operation is one of the major deficiencies of TCA abroad. It is the thesis of this paper that some of the difficulties, failures, and wasted effort could be avoided if those who are best acquainted with culture and cultural processes, namely the cultural anthropologists, were utilized to contribute to the program. Although anthropologists who are area specialists are certainly desirable, it is the type of approach, rather than the body of ethnographic data which a person may have, that is more important. Neither are specialists in applied anthropology essential, since this is not a specialty but is rather the application of knowledge of many different branches of anthropology, whether cultural, linguistic, or physical. Human behavior cannot be predicted accurately, but enough is known to draw certain broad rules which can aid, although not make easy, the type of effort known as Point Four. This paper presents an anthropological conception of technical assistance, recommends a method of approach, and indicates the utility of cultural anthropology in TCA programs. The cultural anthropologists can aid in the following parts of a technical assistance program.

Choice of Field Personnel

The personnel often assigned to technical assistance programs are technicians and administrators who have attained some competence in their fields of specialty in America. But competence in the United States and competence in the field in some foreign country are quite different. Some of the more successful persons in America make a rather poor showing in the foreign field. This is not strange, as the already successful people have a crystallized mode of operation which is adapted to their own cultural background. Success has only entrenched this method. Therefore, success that comes of years of experience and of developing technics suitable to the culture of the United States is not essential, nor even desirable, unless the individual is unusually adaptable and has avoided cultural myopia or ethnocentrism. Further, there are specific racial prejudices in different areas. If wastage of personnel and unnecessary hardship are to be avoided, these prejudices should be considered before people are sent to the field.

Choice of personnel is admittedly difficult, considering the limited attraction of technical assistance employment, but emphasis upon youth, adaptability, technical proficiency, and some knowledge of (or at least a lack of hostility toward) the social sciences seem indicated. The anthropologist can assist in choice of personnel by evaluating the host

* This is not a scholarly or a theoretical paper. It was written in the field. It has neither footnotes nor bibliography. It represents merely the thoughts of the author regarding activities in which he has suddenly found himself. Many of the points brought out may sound strange to a scholar in the United States, but they will not seem so strange to TCA field personnel. It was thought best to present an outline picture of a TCA public health program and to indicate the places where anthropology can contribute. Eveen though not all the aspects of the program are intimately concerned with anthropology, the over-all orientation should be in that direction. The ideas presented, unfortunately, do not necessarily represent any official viewpoint. The author is grateful to those who critically read the manuscript.

culture for racial prejudice and then eliminating those applicants from ethnic groups against which some hatred might be entertained, by judging the applicant's knowledge of the social and cultural sciences, and by determining any ethnic prejudices that the applicant might possess.

Orientation of Field Personnel

Personnel in technical assistance programs should be oriented as to the purpose of the program, the nature of technical assistance, the type of approach, the cultural background and processes, and the physical resources of the country. Technicians and administrators sometimes are overcome by the "big picture." Such personnel have been heard to explain some of their decisions that have sacrificed technical standards on the basis of political wisdom, fighting communism, and as being the advance guard of some future war in which the United States may engage. These political considerations are, of course, important in world politics, but for field personnel they must be relegated to the background. Political expediency has no place at this level. The technicians and administrators should be interested only in bringing about a desired change in their particular fields of competence.

The basic nature of technical assistance, that is, intentional cultural change, must be understood and accepted by the personnel in a TCA program. Once this is accomplished, the type of approach logically follows. This approach consists of determining what are the existing conditions (cultural background and physical resources) and, by adapting technical standards to these conditions, determining the direction in which cultural change is desirable and possible.

The processes of cultural change which should be thoroughly understood by field personnel include the following: diffusion or introduction of new cultural traits, stimulus diffusion or catalytic action of new traits, and invention or discovery and modification of foreign cultural traits by the molding action of the host culture. Different aspects of culture change at different rates, and therefore field personnel should be aware of what to expect when they attempt to introduce a new idea or a new item of equipment. Further, it should be understood that diffusion of culture traits is not a passive process. The host culture may accept or reject a new trait, and it will almost invariably modify, revalue, and reintegrate every accepted trait into its own cultural whole. The recognition of these facts is important and can save wasted effort that might be used in trying to introduce some new idea which a knowledge of cultural background would reveal to be nonacceptable. For example, in one of the Middle East countries, a case of toilet paper for rural schools was procured. A little investigation of the toilet habits of this country would have revealed that such an attempted introduction would be a complete fiasco. Fortunately, the attempt was never made, and the toilet paper is probably being used by American personnel whose toilet habits are also resistant to change. Also, many of the modern drugs introduced into these countries are improperly used, from our standpoint, both as to dosage and as to purpose. These drugs are reoriented into the folk-pharmacopeia of the host culture unless the little culture complex of the drug is introduced along with the drug itself. This is not an easy task. Sometimes a trait, introduced in all sincerity to improve conditions, may have a harmful effect. In so far as is possible, the consequences of any cultural change should be investigated before it is attempted. Of course, it is impossible to anticipate all possible ramifications, but if one is aware of the danger, he is more likely to discover the potentially undesirable effects of his technical assistance.

The Foreign Service Institute in Washington, D.C., functions to orient personnel going to foreign assignments. The brief orientation could be improved by lengthening the course, having more sessions on specific areas, and by insuring language proficiency before personnel are sent to the field. In addition, this orientation should be continued at the foreign post, by emphasis on the people's cultural background, both general and specific, for each particular field of work and the type of program to be carried out. Needless to say, the cultural anthropologist can be of value in this orientation.

Choice of Countries or Areas

Technical assistance is a delicate operation. Success is difficult even under optimum conditions; therefore, the choice of countries is an important consideration. Whether the country in question is important from the standpoint of international relations is a decision to be made by the Department of State. But the type of program indicated for the country should be determined with the aid of one acquainted with the current cultural conditions within that nation. Here, the anthropologist who is also an area specialist can contribute. If the country and its people are hostile toward the United States, the success of a technical assistance program is doubtful. Likewise, if the country lacks natural resources or is under threat of invasion by another country, technical assistance alone will probably fail. Another type of aid may be necessary, such as military or economic aid.

If a technical assistance program is used primarily as a relatively inexpensive program to exert political influence, it will probably fail on both counts. Both the lasting effect of technical aid and the political impression it makes will be nil.

Choice of Type of Program

After technical assistance for a country has been decided upon, the type and extent of the program must be determined. To do this, the existing conditions must be ascertained. The cooperation of technician and anthropologist is essential in this study. For example, in a public health program, the following information should be elicited (similar information should be obtained for other types of programs).

Need. Public health problems vary in time and space. The problems in the United States one hundred years ago are different from those at present. Likewise, the present problems of the United States are not the same as those of some Middle East country. Therefore, it is necessary to investigate the incidence of diseases and to determine which ones have an effect on the economic life of the country. Some diseases, although widespread and a nuisance, have little influence on economic life, and attention to them is not so urgent. Besides, some of them may be improved through betterment of the general living conditions. Other diseases are widespread and preventable and have a deleterious effect on economic life. These are the ones that merit attention.

Cultural background. Disease is universal, and all cultures have some means of dealing with this phenomenon; therefore, it is wise to investigate the following. (*a*) Medical beliefs and practices: some of the medical beliefs are consistent with scientific medicine, and an awareness of this makes the introduction of scientific concepts easier, but even if the beliefs are at odds with modern Western medicine, they afford a cultural base from which to work. (*b*) Sources of disease: attention should be given to methods of disposal of human wastes, to water supply, sexual relations, housing conditions, occupational hazards, and the like. (*c*) Pharmacopeia: some of the native medicines may be empirical and utilizable as cheap sources of effective treatment.

Facts relating to disease conditions. Epidemiology, local vectors, climatological factors, and other natural hazards should be investigated.

Persons and institutions dealing with conditions. It is desirable to become acquainted with the local native practitioners and local national government organizations and to determine their effectiveness.

Possible channels of technical assistance. The anthropologist can aid in choosing the channels that can be utilized effectively in improving the health conditions of the country or area. Some of these possibilities are: governmental organizations, local to national; community action groups; individuals; and charitable organizations.

Planning Types of Activities

After the basic information is gathered, program planning begins. This phase requires the pooled efforts of technicians from different fields of specialization, administrators, and anthropologists. The following points should be considered.

Health conditions to be dealt with. These conditions should be chosen on the following basis. (*a*) Disease incidence: an accurate survey of diseases should be made if this information is not known and also, conditions predisposing toward these conditions should be investigated. (*b*) Effect on economic life: as mentioned, not all diseases have an important effect on economic life. For example, tinea of the scalp is widespread in underdeveloped countries, but although a nuisance, it does not seriously hamper earning a livelihood. On the other hand, malaria, through its morbidity and mortality, is frequently a threat to a family's teetering economy. (*c*) Funds available: although ideally the appropriations for a program should be based upon the existing needs, this does not occur in actuality. Therefore, the funds available for the prosecution of a program should be considered in the program planning. (*d*) Personnel available: often in an underdeveloped country the standards for technical personnel are much lower than in the United States, but the available personnel should not be discarded for this reason. By proper choice, and with supervision and training, many of these can become valuable assets to a technical assistance program. Some of the subprofessional medical personnel have made first-rate public health physicians. Even so, it is necessary to consider available personnel in program planning. (*e*) Consideration of cultural consequences: the program must be designed to produce an improvement. If the program is too sophisticated, no change may result. If improperly designed, some undesirable side effect may result which is worse than the original condition. Consultation with a cultural anthropologist is particularly important here.

Training of personnel. Personnel may be trained by field supervision and classes or they may be sent out of the country for training. Proper selection for the latter type of training is extremely important. Points to be considered are the education and cul-

tural background of the individual, his language proficiency, motivation, general intelligence, and personality structure.

Education of groups. In the field of medicine, there is close association of etiologic concepts and medical practices. For example, if a disease is caused by the "evil-eye", the practice is to avoid or counteract the evil-eye by amulets and other devices. If the scientific ideas of the causation of disease are presented effectively and convincingly, the preventive aspects of a public health program are more easily inaugurated.

Coordination of different fields of activity for mutual support. It is unwise for different sections of a technical assistance program to pursue their goals independently. There are two reasons for a closely coordinated program. A properly designed program avoids unnecessary overlapping of and gapping between functions. The other reason results from the understanding of the functional nature of culture. As mentioned, traits may be rejected or modified by the host culture. If the changes attempted by TCA are integrated into a small culture complex and are consistent with the conditions of the host culture, they have a greater probability of success than if each project were executed individually without regard for the others.

Tie in with responsible native organization. The purpose of working through a native organization is to set up a permanent functioning office to continue activities, once technical assistance has been withdrawn. The organizations may be governmental, community, charity, business, or professional. In this regard, it is necessary to distinguish organizations which have authority for imposing technical standards or insuring quality of work and those which have the responsibility for the operation of institutions or for their support.

Supervision of Execution of Program

After the program is adequately planned, there is then the problem of putting it into action in the field. The difficulties are legion. Compromises must be made. The anthropologists can aid the technician in seeking a compromise that does not lower technical standards too much and in finding cultural channels for execution of activities.

Evaluation of Results of Activities

Not all the results of technical assistance programs are apparent and not all are beneficial. In evaluating a program, one should try to discover the extent and quality of the results. Again, anthropologists can assist in delving into the various cultural recesses and can help to present a total picture of the results of an attempt at intentional cultural change.

This outline picture of technical assistance programs indicates the importance of the contribution of anthropology to such activities. If one gets the impression that there should be an anthropologist behind every technician and administrator, this is an intentional overemphasis to draw sharp contrast to the situation that usually exists in such programs. Actually, although it would help solve the unemployment problem among the anthropologists, it is neither feasible nor desirable. But the basic anthropological approach should be firmly instilled in all personnel, from top to bottom, of the TCA organization and enough live anthropologists should be scattered through the organization to insure that the approach be maintained. As has been indicated, cultural anthropologists have a definite range of utility in TCA programs, and the knowledge resulting from their training and experience justifies positions on the staff ranging from that of high-level consultant in Washington, D.C., to advisor in actual field operations.

If a successful TCA program is to be executed, the following conditions should be observed.

The purpose of the program must be understood and accepted by all personnel. The purpose is to bring about intentional cultural change, in the direction of technical improvement.

The cultural base from which one begins the program must be thoroughly comprehended.

The direction that the program should take should be determined on the basis of the existing conditions in the country, both cultural and physical, and the necessary technical standards that must be observed.

The processes of cultural change, especially in nonmaterial culture which forms a large part of technical assistance, should be understood and the program should be accepted as a slow long-range process.

The importance of integrating all sections of a technical assistance program as a cultural complex for mutual support should be recognized.

Political expediency, which from the standpoint of realistic world politics is necessary, has no place in technical assistance programs in the field.

Deductive Morphology and Genetic Classification Of Coasts

C. A. COTTON

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COASTS, or shorelines, have been variously classified, but a perfect system of classification has not yet been found for them. Systematic arrangement is appreciated by all students faced with the task of describing geomorphic features; for they see the advantage of having some system of pigeonholes with the help of which an unfamiliar and as yet imperfectly understood form can be placed for comparison beside others already known and reasonably well understood. The master geomorphologist W. M. Davis, though he deprecated precise definition, devised and developed explanatory description as a rather loose form of classification, which he made more precise by recognition of stages of the cycle of erosion.

Coast and Shoreline

It has been claimed by Lucke (1938, p. 993) that a specific distinction between definitions of "coast" and "shoreline" implies that a classification of coasts is not necessarily applicable to shorelines, and vice versa. The distinction is one, however, which students ostensibly of shorelines have been unable to make without unduly limiting the meaning of the word "coast" and perhaps unduly expanding the meaning of "shoreline." Johnson's definition restricts "coast" to a belt of land (1919, p. 168); but his studies dealt with a considerably wider zone than this and were certainly not limited to the mere "shoreline," or boundary between land and sea, as the title of his book would seem to imply. Wooldridge and Morgan (1937, p. 360) have remarked: "It is inexpedient, if not impracticable, rigidly to separate coastline and shoreline features."

Valentin (1952), in a recently published work on the coasts of the world, sensibly defines "coast" so as to take in a strip seaward as well as landward of the present-day position of the shoreline, including not only the "shore zones" recognized by Johnson (1919, p. 162) in the existing coast profile but the whole belt at the intersection of land, atmosphere, and ocean—a broad belt in some regions—across which the shoreline migrates, or has migrated from time to time.

The continental shelf itself is part of the coast in so far as it has been partly emergent in very recent episodes of earth history and may have to be investigated when an effort is made to elucidate the history of present-day shores. There is, of course, a tendency to pay particular attention to the visible (and perhaps beautiful) coastscape; the sea floor in front of this being out of sight is in danger of being also "out of mind."

Genetic Classification

Empirical classifications have been based mainly on such distinctions as that between flat (or low) and mountainous (or high) coasts; and others, more ambitious though not fully explanatory, take

into account the geological structure of coastal lands. Thus Suess (1888; 1906, p. 201) has distinguished between coastal terrains of massive rocks together with stratified rocks that either lie horizontally or exhibit a grain transverse to the sea margin, on the one hand, and longitudinally folded coastal belts on the other, thus defining Atlantic and Pacific types, respectively. Though it is implied that fault boundaries are particularly characteristic of the Atlantic type and absent from the Pacific, such a classification throws little light on coastal origins. When "explanatory" terminology and classification have been attempted, practically the only systems so far found to be of wide practical application have been those based primarily on a dichotomous distinction between coasts due to emergence of a sea floor and those produced by (partial) submergence of marginal land, or, as it used to be the fashion to say, between uplifted and depressed coasts.

Very recently Valentin (1952) has attempted a primary separation of *advancing* from *retreating* coasts, which would allow him to recognize *four* main classes, seeing that advance of the shoreline may be due either to emergence or outbuilding of the coast by secondary processes, and retreat may be due either to a movement of submergence or to erosion. The older-fashioned primary distinction between emergent and submergent coasts* relegates erosion and coastwise accumulation to a secondary role, for they have been treated (though perhaps in some cases artificially and even incorrectly) not as taking place contemporaneously with emergence or submergence of the coastal belt but subsequently, in a long or short interval during which no further emergence or submergence is in progress. In such a pause, or stillstand, a marine "cycle" of coastal changes unrolls, characteristic "stages" of which afford further pigeonholes for use in classification. Valentin's alternative, on the other hand, envisages a possibility which certainly should not be overlooked, namely, that in the ordinary process of coastal evolution there are no such stillstands and that upheaval and sinking of coasts, to say nothing of changes of ocean level, are always going on. If this is the case, cliffing by erosion and the outgrowth of deltas and other built features of advancing coasts must accompany, instead of follow, changes of base level. The concept of base level might, indeed, in such cases be abandoned, a noncyclic approach being adopted reminiscent of the revolutionary geomorphology of Penck (1924), which postulates landscape development dominated by secular upheaval, and of objections more recently raised by Cailleux (1950) to the peneplain concept.

* The writer finds it convenient to adopt an artificial definition of "emergent" as meaning having emerged, rather than in the act of emerging; and of "submergent" as partly submerged.

Emergence and Submergence: The Classic Dichotomy

The distinction between emergent and submergent coasts was emphasized by Johnson (1919), but it had already been employed in classification by W. M. Davis (1898) and by Gulliver (1899). This distinction became indeed clear cut much earlier, when the American geologist J. D. Dana, looking down in 1840 on the deeply dissected volcanic island of Tahiti from one of its highest peaks, realized that drowning of the valleys of such a land by submergence must produce a coast with a typically embayed outline (Dana, 1849). Davis (1928, p. 45) has, therefore, recognized this as "*Dana's principle* of shoreline development." As Davis points out, Dana's contemporary, Charles Darwin, though he already believed that volcanic islands subsided, and though he was aware that some of them were deeply dissected by erosion, did not "perceive that the subsidence of dissected islands would give them embayed shorelines." Davis (1928, p. 45) continues: "A notable discovery was therefore left for Dana," who was able "for the first time in the then slow progress of physiographic interpretation" to explain the origin of bays by partial submergence. The view from the mountain top inspired Dana to write: "Sunk to any level above that of 500 feet the erosion-made valleys of Tahiti would become deep bays, and above that of 1000 feet fiord-like bays, with the ridges spreading in the water like spiders' legs." (Compare Photograph 1.) He saw just as clearly that features like these could not be produced by the erosive activity of the sea itself, but must as a rule be eventually destroyed by it.

Submergent coasts constitute a major class in every recognized genetic classification; but this does not imply that all others are emergent. In reality coasts of other origin constitute a composite group, but in such a group those of emergence must figure as an important class.

Gulliver (1899), who was impressed by the value of intricacy of coastal outline as a criterion of submergence, attributed it in all cases to sinking of the land, though Suess had much earlier suggested control by actual change of ocean level, which, in 1888, he termed "eustatic." He had earlier (1880) employed the noncommittal description "positive"

Fig. 1. Map shows location of photographic illustrations.

and "negative" for the (relative) movements of ocean level and of the shoreline which are accompanied by submergence and emergence, respectively, a usage taken up by Richthofen (1886, p. 367).

As regards evidence of emergence, or negative movement of ocean level, marine terraces (Photograph 2) and young, that is, little dissected, coastal plains are generally acceptable—though the distinction between the latter and strand plains must be kept in mind. ("Strand plains," so called by Davis, have been built out from a hinterland by beach accumulation while sea level has remained stationary, whereas true "coastal" plains are exposed strips of former sea bottom.)

Gulliver realized the necessity of making allowance for oscillation of level, which he thought of, however, as oscillation of the land, the ocean level remaining unchanged. He, and Davis also, was impressed by evidence of oscillation of the coast of Maine, where features due to recent upheaval, attributable to uprise consequent on unloading of the crust due to melting of the continental glacier, fringe a drowned land margin.

The recognition that considerable oscillation of the ocean level itself must have taken place, as much ice has accumulated on the lands in glacial ages and has melted away again, dispenses with the necessity for assuming oscillation of the land; but neither Gulliver nor Davis realized this fifty-five years ago. Davis began to make allowance for such glacio-eustatic oscillation only when his attention was drawn to it by R. A. Daly in the coral-reef controversy; and apart from the coral-reef question he gave little attention to its implications until confronted with a problem of marine terracing in Southern California, when he attributed the terrace-making to rapid cliffing back of the coast at times when positive movements of ocean level overtook and outpaced a continuously operating upheaval of the land (Davis, 1933).

PHOTOGRAPH 1. Submergent coast resulting from deep drowning (plus postglacial redrowning) of mountainous land, Queen Charlotte Sound, Cook Strait, (N. Z.). (From N. Z. Ministry of Works.)

The Marine Cycle: A Device for Classification

In his *Physical Geography* Davis (1898) classified "shorelines" on the twofold basis, placing those of emergence in a "first" class ("where the sea lies on an uplifted sea bottom") and those of submergence in a "second" class ("where the sea lies on a depressed land surface"). Such separation of main categories is applicable more especially to initial, that is, as yet uneroded, forms of the coast; but for subdivision Davis outlined cyclic erosional stages characteristic of derived, or sequential, forms in each class separately. His brief treatment of the cyclic development of emergent coasts assumes the outline of the new land to be straight or nearly so, an inference which is usually more justifiable in the case of emergence of a new coastal plain with appreciable slope seaward than in the only case Davis subjected to analysis, that of extremely gentle declivity.

In such a case the slope of the adjacent sea bottom, continuing that of the newly emergent land, is so gentle that sand is stirred up from the bottom by breaking waves in the process of development of a graded under-sea profile, and thrown up, in a manner already recognized by Élie de Beaumont (1845), as a long "sand reef,"* which emerges from the sea some distance out from and parallel to the initial shoreline.

Cyclic Development from Emergent Coasts. The sand reef, or barrier, encloses a "lagoon," and its continuity is broken in places by gaps ("inlets") kept open by tidal currents. The barrier or chain of barrier islands so formed has some degree of permanence, for, as pointed out by Davis, "about as much sand is brought in from the sea-bottom as is ground up on the beach and taken away." Subsequent conversion of the lagoon into salt marsh

* Davis (1896) had earlier called this feature an "offshore bar"; he continued later (1912) to call it a "sand reef," but offshore bar was preferred by Johnson (1919). More recently Price (1951) has proposed to substitute "barrier island" for this as usually applied. "Barrier" was used by G. K. Gilbert (1885, p. 87), and has continued in use as a synonym (Cotton, 1922, p. 389; 1942b, p. 432). Shepard (1952) has suggested a general use of barrier for above-water and "bar" for under-water ridges of sand, but proposes no genetic significance for this distinction between barrier and bar.

PHOTOGRAPH 2. Coast of emergence, North Canterbury (N. Z.). A coastal plain has been cut back by marine erosion to a narrow terrace. (By V. C. Browne.)

by infilling is followed, in the normal course of events, by retreat of the shore under wave attack, this having become possible owing to offshore deepening brought about by removal from the bottom of the sand that has been thrown up as a barrier. All the salt-marsh flats may eventually be cut away in this process, so that now "the mainland is directly attacked and slowly cut back in a long low bluff," or line of cliffs. Thus a cyclic stage of coastal development is reached which Davis later called "maturity." He was unable, however, to find examples of coastal-plain coasts cut back so far by the sea that they "terminate in cliffs of great dimensions" (1898, p. 355). The high chalk-cliffed coast of Normandy (northwest France), which he mistakenly described at this time as such (but an "exceptional case") he later (1912) diagnosed as due to continuous cliffing of an initially submergent (not emergent) coast.

Davis did not, either at this time or later, realize the importance as a coastal type of the other case in which the offshore profile of an emergent coast is relatively steep, though he was not unaware of examples of cliffing at the margins of some rather steep coastal plains immediately on their emergence, so as to cause elision of the barrier-fringed stage of development (Davis, 1896; 1909, p. 709). Owing, however, to failure of the classic systematists to analyze the development of such coasts, which are characterized by marine terraces, emergent coasts on which these are prominent features for long escaped full recognition.

Cyclic Development from Submergent Coasts. Davis outlined also a cycle of sequential forms derived from his "second" (submergent) class of coasts; but he did not follow this out beyond the stage he later called "submaturity," that at which headlands are cliffed and the mouths of bays are bridged across by the extended growth of spits of sand or gravel, leading to great simplification of coastal outline (Fig. 9, *A*, *B*, *C*).

Oscillating Coasts. Davis was, like Gulliver, well aware of complications in the developmental history of coasts which are due to oscillation of level.

A coast previously submergent might emerge, so that "its former cliffs and beaches may be found at a greater or less distance inland." Thus the "compound" category of Johnson (1919) was foreshadowed. The existence of coasts (later termed "neutral" by Johnson) which could not be classed as either submergent or emergent was also recognized by Davis, for he described "delta shorelines" in a separate category.

The "Outline of Cape Cod." The elementary, but systematic, treatment of coasts in Davis's *Physical Geography* had been preceded two years earlier by a deductive essay on coastal forms with special application to those of Cape Cod (1896), in which he analyzed development of shore profiles and shore outlines separately. In his discussion of the coastal profile the concept of a "graded condition" was introduced, with also the idea of a cycle of development. "A graded profile being once attained, its graded condition will be preserved through all the rest of an undisturbed or normal cycle of shore development" (Davis, 1896; 1909, p. 702). The grade and cycle concepts were found useful also in the treatment of outline. "The initial irregularity of shore outline [due to submergence] is replaced by a graded outline," during the cyclic change from a youthful to an "adolescent" (in later writings termed "submature") stage. The "graded" outline he described is the rectified line resulting from a trimming back of headlands under wave attack and a bridging of the mouths of bays by "bars" (so called by Gilbert, 1885, p. 92). Davis felt it necessary to distinguish these as "tangent" bars, named from their relation to shoreline drift,* for, disregarding Gilbert's term "barrier," he had substituted "offshore bar," a name destined to survive for years, for the description of ridges of sand "built up from the bottom in shallow water."

He developed the theory of development of these offshore bars, but without at this time specifically declaring them characteristic of emergent coasts. They enclose lagoons, and this early stage is followed by filling of the lagoons, migration of the barriers landward, and eventual elimination of the ensemble of fringing features during the progress of a cycle in which he recognized stages of youth and "adolescence." His statement of this cycle is a model of clarity. Illustrated by prototypes of diagrams employed later by Johnson, it is on the lines of later treatments by Davis himself (1898; 1912) and by Johnson (1919).

* Without questioning the diverse origin of such bars ("bay bars" of Johnson, 1919), Shepard (1952) has included them in an empirical category of "barriers" along with offshore bars ("barrier islands").

Gulliver's "Shoreline Topography." Further exploitation of the "cycle of shore development" recognized by Davis in 1896 was left to Gulliver (1899), according to whom "the forms of any coastal belt [N.B. not merely shoreline] may be grouped in the appropriate stages of a cycle. These forms will be consistently related to the associated land area on the one hand and to the sea bottom on the other. When considered together, the forms of a coastal belt indicate the relative time since the last considerable uplift or depression, as well as the ratio existing between the several activities, in their dynamic effect upon the forms of the coast and the shore."

Gulliver's work is in the main a study of topographic maps selected from various regions, the maps being sorted, with an eye to classification, into two groups, the first to demonstrate and classify "initial" forms and the second "sequential." Initial forms, on which primary classification must depend, are grouped as originating from: (1) uniform uplift, (2) uniform depression, and (3) diverse movements. The third category foreshadows coasts of "transverse deformation" (Cotton, 1942a, b); but few maps were available to Gulliver for the study of these, and the only example he found it possible to cite of strong differential movement bringing close together coastal features attributable to emergence and submergence was in Southern California. There, following Lawson (1893), he recognized that coasts with high flights of marine terraces on the mainland at San Pedro and the island of Santa Catalina had between them the partly drowned island of Santa Barbara.

European Classification

An important discussion of coasts was included by de Martonne (1909) in the first edition of his monumental textbook of physical geography. His use of the concept of a "cycle of littoral erosion" was limited to an account of the straightening, or rectification, of the outline of a coast initially embayed by submergence. Stages of youth, maturity, and senility were recognized; but that termed "maturity" was "adolescence" of Davis, later termed "submaturity" by Davis and by Johnson, while "senility" was the equivalent of "maturity" in the usage of Davis and Johnson.

In the classification of initial forms the categories of emergence and submergence, though not specifically mentioned, are recognizable in the main divisions: (1) coastal plain types (emergence), and (2) coasts of folded regions (implicitly assumed to be embayed by drowned valleys). Here, following

Richthofen,* a distinction, of minor value in *genetic* classification, is introduced between types based on contrasting geological structures of the land, whether the grain of the terrain is parallel or transverse to the general line of the coast. Naturally, where a mature land with valleys adjusted to geological structure is invaded by the sea, *geographically* contrasting types of outline are found in these two cases.

In addition to those listed above, a miscellaneous assortment of other categories of initial coasts are mentioned, such as fault, volcanic, and glacial coasts.

Coastal Morphology in Davis's "Erklärende Beschreibung"

The treatment of coasts by Davis in his German textbook (1912) was extensive as regards process and stages of development, but he did not specifically recognize primary categories of initial coasts other than the "first" and "second," or emergent and submergent, classes. He again discussed separately the modification by marine processes of profiles and outlines; it is noteworthy that this time he specifically set out to describe not shorelines merely but "coastal forms" as these develop in a "marine cycle," with "initial," "sequential," and "ultimate" forms. Consistently with cyclic treatment, the ocean level is assumed to remain constant (in relation to the land) during development. Necessarily stillstand both of land and of ocean level must be very prolonged if advanced cyclic development, as deduced by Davis, is to take place with the formation of a broad wave-abraded platform that grows in width progressively at the expense of the land at the foot of complementary retreating cliffs, for, toward the last, when the shoreline has receded far and the abraded platform has become wide, cliffs must retreat very slowly indeed. He did not, however, ignore the possible alternative of much more rapid, noncyclic erosional destruction of a coast that is cliffed back progressively with constantly rising water level, or sinking of the land (1912, p. 518), as it had been visualized by various geologists, notably Gilbert (1885, p. 110) and Richthofen (1886, pp. 353–361). (Gilbert pointed out that with "slow and gradual submergence . . . the erosion of sea cliffs is exceptionally rapid, because the gradually deepening water upon the wave-cut terraces . . . enables [the waves] to spend their full force against the cliffs.") Davis again invoked this mechanism to account for rapid coastal erosion, in 1928 (p. 194) and in 1933.

Emergent Coasts. Davis discussed at considerable length the erosional changes affecting coastal outline; but his treatment of emergent coasts was still incomplete, being based on the tacit assumption that there was only one case worthy of consideration, namely, that one with so gentle an initial slope of the sea floor seaward that cyclic development must begin with a deepening of the sea offshore and a piling up of the sand so derived into a barrier. His analysis of further development of this coast was presented on similar lines to his earlier treatments (1896, 1898). He now described such a coast as "young" while it was bordered by barrier islands and the more or less infilled lagoons they enclose, and "mature" when these are eliminated in the course of cyclic change and a line of cliffs borders the low coastal plain at the rear—an example of this stage being the Adriatic coastal-plain coast of Italy.* An "old" stage, Davis suggested, might be defined as that which will be reached when the coastal cliffs, retreating more and more slowly and progressively gaining height, though still in coastal-plain strata, lose the steepness they retained when the coast was mature because they are now subaerially graded. The slowing down of cliff retreat which allows of this is due to increasing width of the complementary abraded platform seaward of the shoreline, which absorbs the energy of breaking waves. Elimination of the coastal plain and cliffing back into the hinterland are not envisaged.

Submergent Coasts. The remainder of Davis's (1912) discussion of coasts consists mainly of an elaboration of the scheme of cyclic development of embayed coasts (those of his "second" class). He described the focusing of wave energy by refraction on headlands, which are therefore actively trimmed back; development of beaches and spits and the bridging of bays by bars; infilling of bay heads and bar-enclosed bays; and so forth. The coast is to be termed "submature" when its outline, initially intricate, has been smoothed by these processes; and "mature" only when, or where, erosion has forced the shoreline to retreat beyond the heads of the initial bays (produced by drowning of valleys) so

* The classification of Richthofen (1886), though it introduces numerous *types based on localities* and though it is not a *genetic* classification, did recognize one principal genetic group, that in which the sea "invades" valleys of the land. Subdivisions of this group are: (1) fiord coasts, (2) the Dalmatian type, with trend parallel to the grain resulting from folded structure of the land, and (3) rias coasts, with trend transverse to this grain. Though the name "ria" was taken from that locally applied to the bays of northwest Spain, the chief examples cited of rias coasts were those of Brittany and southwest Ireland, in both of which the general line of the Atlantic border is transverse to the strike of the Armorican structure to which landscape ridges and valleys are adjusted.

* As noted later, this is a concept of maturity differing from that of Putnam.

that the line of cliffs has become continuous. Such a definition of coastal maturity as synonymous with development of an unbroken line of wave-cut cliffs is acceptable with application to coasts in general, in whatever way they were initiated.

Davis described the chalk cliffs of northwestern France (facing the white cliffs of Dover, which are similar) as a coast of submergence now in the fully mature stage of development. The outline is certainly fully mature; but Davis (1912, p. 513), as Johnson (1919, p. 250) has pointed out, elliptically described the cliffs themselves as late-mature instead of as cliffs of a fully mature coast. In a cycle of erosion formulated for the cliff form itself—apart from the cycle of coastal development—the cliffs must, as Johnson claims, be called "young," because they are retreating so rapidly that they remain nearly vertical.

Davis was aware of the rapid retreat of the chalk coasts; he was so impressed by it that he at one time (1898, p. 356) attributed the separation of Great Britain from Europe at the Strait of Dover to marine erosion, though familiar with the biological evidence which indicates a very late date for this separation. It is known now, however, that the retreat of these cliffs, though measurable, has been quite small since the reopening by drowning of the Strait of Dover when the ocean water returned only a few thousand years ago (after the drying out of the Strait during the last glacial age).

The chalk coast of northwestern France is an example cited by de Martonne, as well as by Davis, of coast retreat so far advanced that rivers are betrunked (so that valley mouths now "hang" above sea level); some river systems are even dismembered so that former tributaries now enter the sea independently. The great retreat thus indicated suggested to Davis (1912, p. 485) possibility of a secular sinking of the region, which would keep wave action vigorous while it was in progress. The retreat has certainly been going on for a long time, though it has necessarily been interrupted by the glacial-age episodes of low ocean level. Davis did not realize the short duration of postglacial time.

Miscellaneous Coasts. Davis indicated how interruption of a marine cycle must take place, with initiation of a new one, if relative levels of sea and land change. Being little interested, however, in formal definition and in tabulation, he did not extend his classification beyond the two main classes by enumerating miscellaneous initial categories of coast which are not conveniently included in either, such as volcanic, glacial (fiord-wall), or tectonic (fault and monoclinal) coasts. He did, nevertheless, describe, though without placing it in any special category, one of those coasts which are transversely warped so that forms due to upheaval and submergence appear side by side—the Italian Riviera di Levante (Fig. 2).

He also indirectly attacked the question of fault coasts by suggesting other explanations for the Atlantic coasts which Suess (1888; 1906, p. 203) had claimed as due primarily to foundering of former land to seaward along great fractures. As a specific example he described the coast of Cornwall and Devon (Davis, 1912, p. 502), offering an explanation of it which is an extension of his "morvan" concept of mountain form, embodying the principle of intersecting peneplains. A strip of the more ancient of two intersecting peneplains, which is steeply inclined and which has been buried under strata and much more recently re-exposed by erosion, forms a nearly rectilinear range front—that of the Front Range of the Rocky Mountains in Colorado being a typical example. The initial outline of a "morvan" coast might be most simply pictured as resembling that which would result from such Noachian flooding of North America as would allow the sea to lap against the Rocky Mountain front.

Systematic Treatment by Johnson

In Johnson's major work (1919) he enlarged the classification of coasts by adding other primary categories to the already well-established emergent and submergent classes. One, which he termed "neutral," was designed to include those coasts the essential characteristics of which depend on causes other than change of level, or submergence and emergence. Necessarily this is a miscellaneous group, including: (*a, b, c*) delta "shorelines," alluvial-plain "shorelines," and outwash-plain "shorelines" (though these are scarcely separable from one another); (*d*) volcano "shorelines," described as "of more or less circular pattern"; (*e*) coral-reef "shorelines"—not only fringing reefs but all such, for all are "independent of changes of level," the outline marking the "contact . . . with newly made land in progress of formation"; (*f*) fault "shorelines," that is, *newly made* fault scarps, the infantile slopes of which have descended below sea level.

Johnson's fourth main category, which he termed "compound," was created to meet the case of coasts that "combine elements of at least two of the preceding classes." This indispensable, not to say omnivorous, group includes more particularly those coasts which preserve features impressed on them as a result of both positive and negative movement of an oscillating ocean surface (or, alternatively, of oscillatory diastrophism).

In subdividing submergent coasts Johnson (1919) abandoned the traditional (European) distinction between "rias" coasts (Richthofen, 1886; de Martonne, 1909) in which the coast crosses the grain, or strike, of structures of the marginal land, and a "Dalmatian" type of coast, with the grain parallel to the generalized coast line so that a trellised pattern of valleys is drowned. He included both these types under the one head of "ria shorelines." In addition to these he placed fiord shorelines in the submergent class, that is, those formed by the entry of the sea into troughs excavated by glaciers, though such entry does not require a change in relative levels of land and sea. Inclusion of these in the same class with normally drowned coasts seems tacitly to indicate close community of origin, but it was not Johnson's intention to imply that the submergence of fiords was necessarily accompanied by either sinking of the land or rise of ocean level.

Sequential Forms of Submergent Coasts. Johnson, like Davis, made use of the stages of cyclic coastal development for subdivision of his genetic categories, particularly that of submergent coasts.

In a stage of early youth a coast of submergence, which might alternatively have been called "infantile," was termed by Johnson "crenulate." Characteristic of this stage (recognized and figured earlier, though not so named, by Davis) is a small-scale irregularity of outline which has early replaced smoother curves of the initial line of intersection of the sea-level plane with a dissected land. Development of this condition may be expected to follow quickly upon submergence, because of the vigorous activity of wave erosion, picking out small differences of rock resistance and so revealing the bare ribs of any small-scale heterogeneity of terrain, when it begins to work on the moderately inclined to rather steep shore profiles afforded by submergence of land slopes.

"Maturity" was reserved, as it had been by Davis, for a late-developing condition of continuous coastal cliffing, which, in the nature of the case, is very long delayed if the embayment of the coast by drowning has extended far up the valleys. In conformity with Davis's usage (1912) he described as "submature" the important and long-enduring stage that begins with the rectification, or smoothing, of the outline of the shore brought about by the truncation of headlands and the building of "bay bars" as barriers across bays. A continuous strand thus developed affords a path for transportation of gravel or sand alongshore, some of which finds temporary lodgement in the shore zone, forming beaches (Fig. 9, *C*).

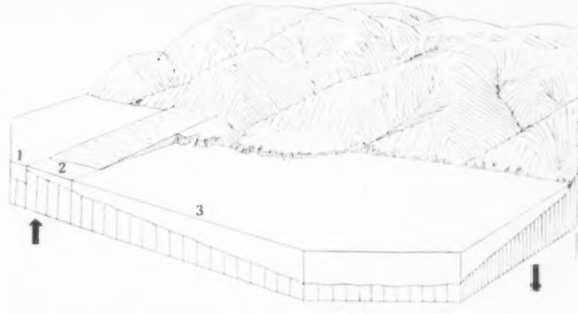


FIG. 2. Diverse movement of the Riviera di Levante coast, Italy, as interpreted by W. M. Davis. (1) Earlier condition, followed by (2) deformation (local by upheaval), (3) features of existing coast generalized; upheaval (at Genoa) to left; submergence (at Santa Margherita) to right. (After a diagram by Davis.)

Mature Coasts. Johnson neglected to take structure of the land fully into consideration in the analysis of mature coasts. When a coast is thus cut back to a continuous line of cliffs, whether from a shoreline initially embayed by submergence or from any other initial outline, the line of cliffs may be nearly straight, as it is shown in Johnson's diagram of the mature stage (1919, Fig. 88); but this will be only in the special case of homogeneous rock terrain, as, for example, in the chalk cliffs of France. If a definite structural grain in the landmass be allowed for, such as is present at Wellington (N. Z.), a grain sufficiently well marked to produce adjustment of the mature ridges and valleys of the landscape to the structure, this must be reflected also in an adjustment of the mature coastal outline to the same structure, so that the line of cliffs will be far from straight. In the case of the cliffs on west and south coasts at Wellington (Photographs 3 and 7) maturity of outline is provided by continuity of the line of cliffs, but the outline is strongly sinuous (Cotton, 1951a, p. 104; 1952a, p. 55). On the somewhat embayed coast thus produced cliffs are continuous around bay heads as well as headlands. Profiles and details of the cliffs indicate that vigorous marine erosion is in progress, so that the cliffs must now be retreating rapidly. Yet, generally speaking, the coastal outline will not become any more nearly straight. Johnson did not realize how intricate a maturely developed shoreline may become through such adjustment to structure, and pictured it with only broad and "simple but distinct" curves (Johnson, 1919, p. 344). He was aware, however, that, while at an earlier stage there will be "more rapid retrogression of the shoreline on weak rocks," after "maturity is attained . . . all parts of the shoreline retreat at the same rate."

Sequential Forms of Emergent Coasts. John-

PHOTOGRAPH 3. Maturity of development indicated by continuous cliffing, with outline adjusted to structure. Cook Strait coast, near Wellington (N. Z.). Postglacial eustatic submergence has here been neutralized by probably concurrent upheaval. (From N. Z. Ministry of Works.)

son's typical emergent coast ("shoreline" of emergence) was (following Davis) that bordering a low, broad coastal plain which is fringed (in its infancy) by barriers; but he pointed out that features of sequential development such as (still following Davis) he described as *characteristic* of such coastal-plain margins might be found on some coasts that are not emergent, where, for example, very nearly level land surfaces have become slightly submerged (1919, p. 201). He thus anticipated and supported in advance a perfectly valid claim made more recently that such features are not *criteria* of emergence (Shepard, 1937). It will not be out of place to mention here another cause of upgrowth of offshore barriers which is independent of changes of level, namely a shallowing of the sea by infilling with disturbance of pre-existing equilibrium of profile, such as will result from *showering* of abundant sandy debris of volcanic origin. Such development of a coast that would be placed in Johnson's "neutral" category appears to have been the origin of the sand-built barrier island at Tauranga (N. Z.) (Cotton, 1942b, p. 433; 1951b, p. 349), which fringes a drowned coast along the dissected margin of a terrain of volcanic rocks (not a coastal plain) (Fig. 3). It is known that at least one explosive eruption of extreme ("Plinian") violence has showered rhyolitic volcanic ash in this vicinity at a date which must be later than that of the postglacial drowning of the coast* (Cotton, 1944, p. 190).

* Radiocarbon investigations have shown that these volcanic "showers" fell within the last 3000 years.

Johnson's discussion, like that of Davis, was limited to the case of emergence of a sea floor not far from dead level. He did not, apparently, consider it worth while to analyze a hypothetical case of emergence with steeper submarine slope seaward. One of the few later suggestions to include such (in part terraced) coasts within the purview of coastal classification has been made by Putnam (1937), who has outlined the marine cycle for a "steeply sloping shoreline (*sic*) of emergence." This is the process of further narrowing an initially narrow coastal plain by cliffing, so that it is reduced shortly after its emergence to a marine terrace, marking "early youth," and further narrowed in "late youth" (stages which might respectively have been called *youth* and *submaturity*). This is followed by ultimate destruction of the terrace by continued wave attack, when the hinterland becomes cliffed so as to make of it a typically *mature* coast (Fig. 4).

Such development may take place in a small fraction of the time that would be required to produce a similar mature, that is, continuously cliffed, outline by cliffing back an embayed submergent coast of similar rocks. As a consequence, emergent coasts retrograded to a continuous line of cliffs (Photograph 3) are relatively common (Cotton, 1951a, p. 103; 1953a, p. 54). There are also very numerous examples known of the younger stage at which marine terraces survive (Fig. 5 and Photograph 7).

In his discussion of the sequential history of a coast on which "offshore bars" (barriers) are formed (on the lines of the earlier classic treatment by Davis) Johnson retained Davis's description of the coast as young while it remains fringed by barrier and lagoon, and mature when the lagoon has disappeared and the barrier after having been driven landward has eventually been eliminated, so that cliffing of the margin of the coastal plain at the rear begins. The aspect of the coast, continuously cliffed from now on, contrasts so strongly with its former fringed condition that it seems appropriate to retain this definition of maturity. It would seem unrealistic to insist instead on the analogy of this marginal cliffing with the cliffing back to a marine terrace of the much narrower coastal plain that emerges bordering a high coast with relatively steep submarine profile. In that case all stages of the cliffed, marine-terraced condition are by definition young (Putnam, 1937), or at any rate no farther advanced than submature; maturity is achieved only when cliffs are cut back into the hinterland, a condition which does not always require a very great span of time for its attainment. In the Davis–Johnson case, on the other hand,

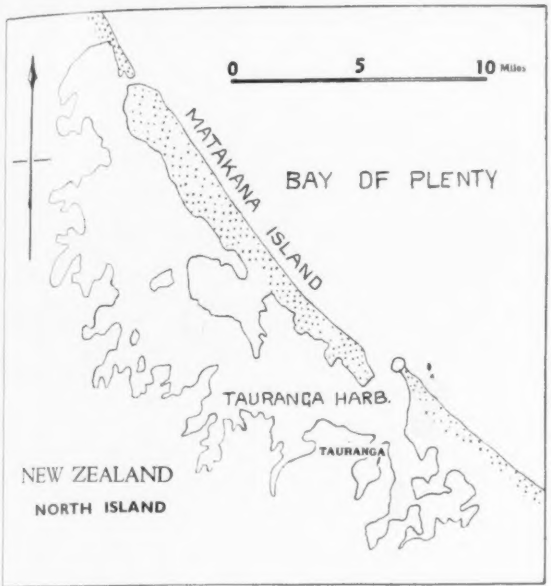


FIG. 3. Barrier island (Matakana Island) enclosing Tauranga Harbour (N. Z.) as a lagoon. This borders an embayed coast at the submergent margin of a dissected terrain of volcanic rocks.

maturity would in most cases be indefinitely postponed if it were delayed (by definition) until a broad coastal plain of gentle declivity had been destroyed by marine erosion, even though such destruction might theoretically be remotely possible.

Cliffed Mountainous Coasts. In New Zealand there are some mountainous coasts bordered by continuous or almost continuous cliffs (examples at Wellington have already been mentioned) which apparently have been developed during retreat *of moderate amplitude* either from tectonic scarps or from very steep coasts of emergence. Described examples of coasts bordering mountainous land that has been cut *far back* by marine erosion have been hard to find, however, in regional geographical reports that can be accepted as geomorphically trustworthy, whether scarps so formed remain coastal or have been forced inland by more modern advance of the shoreline. Two major scarps were cited as examples by Johnson, one along the rear margin of a fringing plain in southern India and the other backing the "strandflat" of Norway; but the correctness in each case of the explanation of the scarp as due to marine cliffing may be doubted (Cotton, 1942c, pp. 85, 197).

Johnson theoretically developed the concept of secular retreat of cliffs on a coast of submergence, carrying the analysis even further so as to include the case in which a landmass is largely or perhaps wholly cut away by erosion (at "old age" of such a cycle of development). It can be deduced that a large area of land may thus be progressively replaced by a surface worn flat by abrasion at a level considerably below that of the sea (Johnson, 1919, p. 256). This is a theory of some geological importance, but, as it implies an almost infinitely prolonged period of stability of sea level, a condition not compatible with the oscillation known to have occurred rather recently, it is not helpful in explanation of the origin of existing coasts. Richthofen's theory, previously referred to, of somewhat similar development accompanied by rapid coastal cliff retreat during a relative (and commonly real) rise of sea level demands much less time and seems applicable to some coastal segments in soft-rock terrains.

Fault-Scarp Coasts. In his book *The New England—Acadian Shoreline* (1925), Johnson was more specific than he had been in 1919 in justifiable limitation of the definition of true fault coasts. It is not enough that the sea now laps against a fault scarp, for in the great majority of instances in which this is the case the present outline is due to recent submergence, so that the coast must strictly be placed in the primary submergence category. If it has clearly been a fault coast prior to a recent positive movement of ocean level (or a general subsidence of the land), it can be placed also in the "compound" group (for it can be claimed as a fault

FIG. 4. Stages of erosional development of an upheaved coast. (After Putnam.)

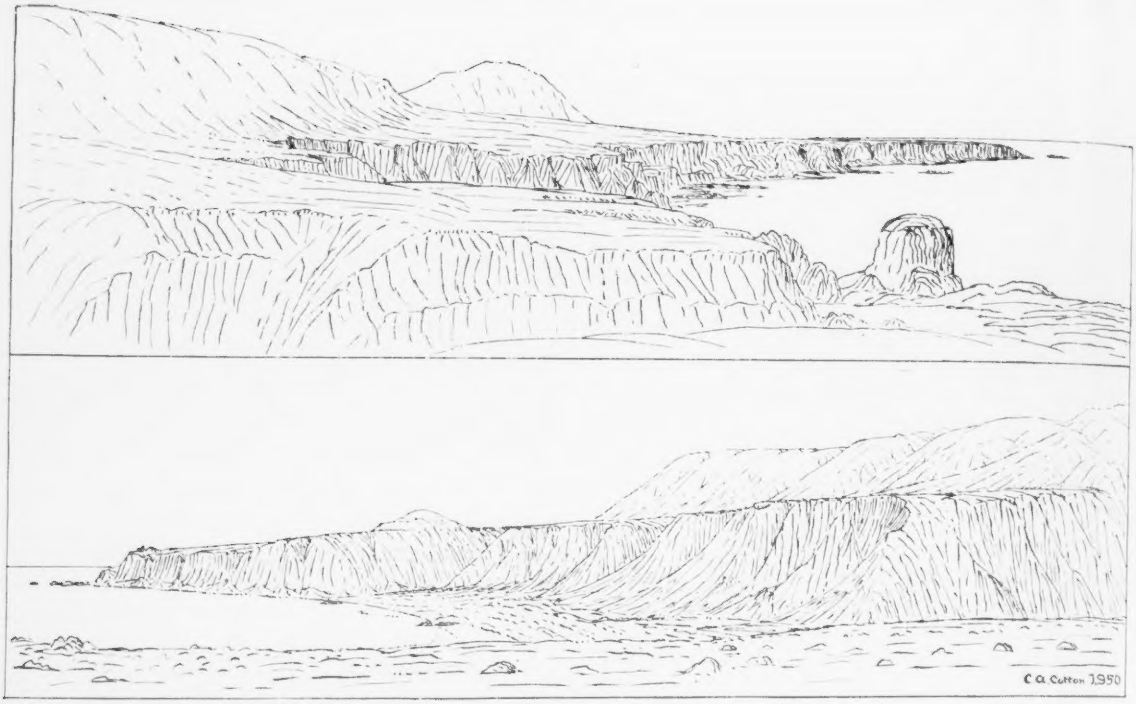


FIG. 5. Young erosional development of emergent coast (from a photograph). Above, on Islay Island, west Scotland (reputedly postglacial emergence). Below, Baring Head, Wellington (N. Z.) (possibly postglacial emergence).

coast in a second cycle). If, however, it has not been a fault coast in a former marine cycle, a coast formed by intersection of the present level of the ocean with a fault scarp is, in technical terminology proposed by Johnson (1925, p. 32), a "fault-scarp" (not "fault") shoreline, or coast, although, as he has pointed out, the class thus defined is merely a subdivision of submergent coasts. (As shown in Fig. 6, it cannot but be embayed to a certain extent.) He claimed, on the other hand, that the place of a true fault coast was in his "neutral" category. Among submergent coasts, he observed that some other rectilinear examples were of a "fault-line-scarp" variety, in particular some parts of the New England—Acadian coast, which he described.

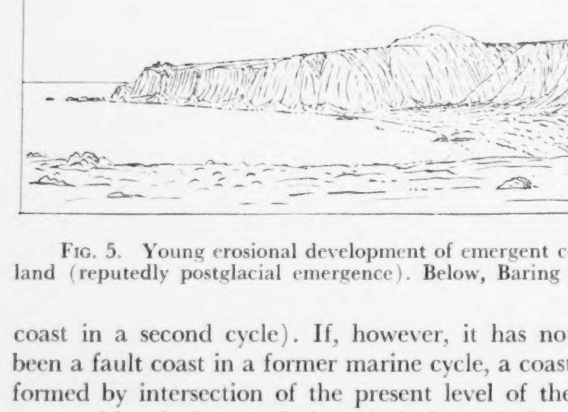


FIG. 6. A straight coast produced by partial submergence of a landscape traversed by a fault scarp or fault-line scarp. *A*, dissected condition prior to submergence; *B*, after a rise of ocean level (or regional subsidence).

Shepard's Classification

Shepard's classification of "primary," that is, young or initial, coasts, as set out more recently in *Submarine Geology* (1948, pp. 71–73), was proposed in 1937. It is chiefly remarkable for its abandonment of the classic dichotomy of categories of emergence and submergence, for its author refuses to recognize the existence of emergent coasts anywhere. A dichotomy substituted (though this is not apparent from the author's tabulation, which presents four main heads) is one between coasts of submergence (A, below) and a group of others (B, C, and D), which might all be placed in Johnson's "neutral" category. The classification is as follows:

A. "Shaped by terrestrial erosion and drowned by deglaciation or downwarping" and, we may add, positive movement of ocean level. Here are included "ria coasts" and "drowned glacial-erosion coasts."

B. "Shaped by terrestrial depositional agencies."

PHOTOGRAPH 4. The fault-bounded outer coast of mountainous Fiordland (southwest New Zealand). (By V. C. Browne.)

Here are included coasts formed by "river deposition," "glacial deposition," "wind deposition," and "vegetation extending the coast."

C. "Shaped by volcanic activity."

D. "Shaped by diastrophism," including "fault-scarp coasts" and "due to folding," that is, monoclinal coasts.

It would be difficult to agree with Shepard's rejection of emergent coasts as a worth-while category in classification. It appears that, being misled by the conspicuously incomplete treatment of emergent coasts offered by Davis and Johnson, he has failed to realize the significance of important features indicative of emergence, such as raised beaches and marine terraces, and has thus focused too closely on the doubtful "criterion" of offshore bars. The regions affected by postglacial isostatic "rebound," when relieved of a heavy load of ice by its melting, afford abundant evidence of genuine upheaval of coasts, as do also many parts of the "mobile belts" of the world—parts in which diastrophism is still active. Writing in the same year as Shepard, Wooldridge, and Morgan (1937, p. 357), though fully aware of the fact of a postglacial rise of ocean level that has affected the coasts of the world very generally, continued to regard the distinction between emergent and submergent coasts as of first importance in classification.

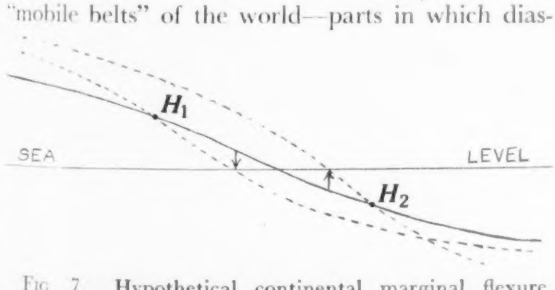


FIG. 7. Hypothetical continental marginal flexure. H_1, H_2: Alternative positions of the hingeline of flexure.

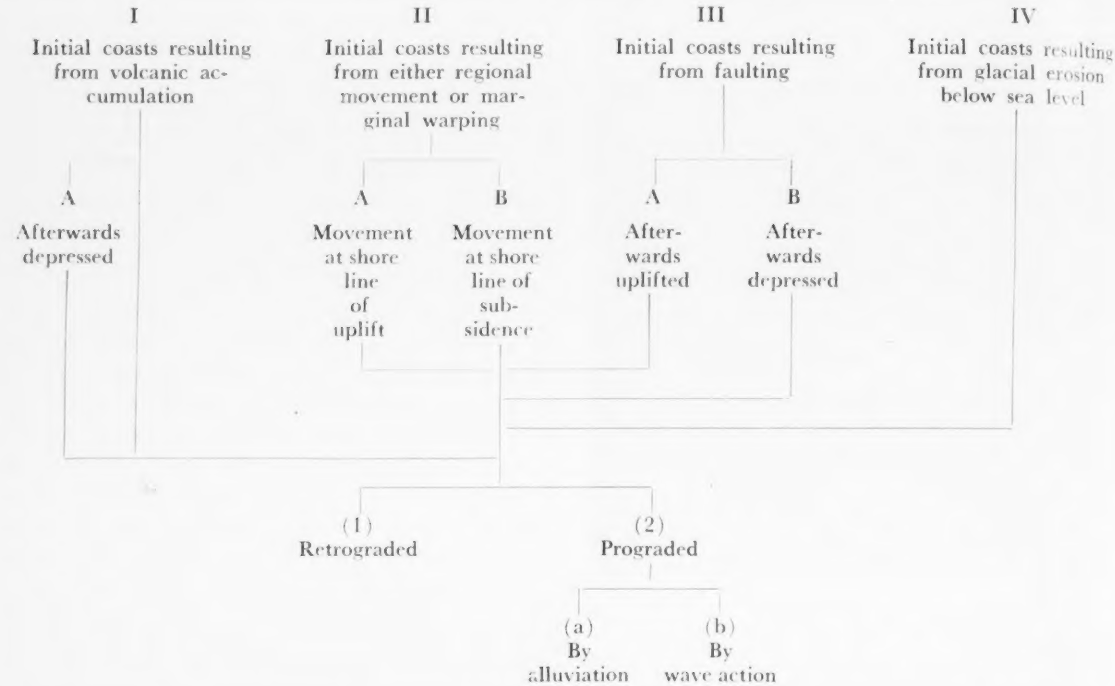
Even if it could be granted that the postglacial rise of ocean level was so recent, or, conversely, that recent diastrophism has been so feeble, that every coast must now afford evidence of drowning as a result of it, there are so many coasts still dominated by features imposed on them by earlier, though not very remote, uplift that discussion of the features of such coasts is desirable and necessary. Geomorphologists must be prepared also to restore the appearance of the coasts initially, immediately after their uplift, in whatever more or less ancient cycle that took place. Such compound coasts cannot logically be left out of a scheme of genetic classification unless it is confined very strictly to "shorelines" (in a restricted sense) as they now are, that is, to "secondary" features, as defined by Shepard (1948, p. 70).

PHOTOGRAPH 5. Monoclinal-flexure coast, north of Karamea River (N. Z.). Note the hogback ridge on a seaward-dipping homocline of young covering strata. (By V. C. Browne.)

The Continental Marginal Flexure

In a scheme of classification proposed in 1918 (Cotton, 1918) and since used in textbooks (Cotton, 1922, 1942b), the possibility has been recognized not only of regional movement uniformly up or down (now more conveniently explained in many cases as movement of ocean level) but also of marginal warping or flexure of the landmasses on longitudinal axes, that is, parallel to coasts. Either one or other or some combination of these may produce coasts of the two main classes, emergent and

Classification of Coasts (Cotton, 1918)



submergent. The idea of an inherent tendency of lands to rise and of ocean floors to sink, which has been given prominence in recent writings by Bourcart (1950), has long been a familiar one in geological theory. It was a favorite theme of T. C. Chamberlin's and was implied in Davis's preconceptions of land and coast development; even the elementary concept of the coastal plain, in the geological sense, implies a seaward tilting which has given coastal-plain strata an appreciable inclination away from their hinterland.

Assuming such marginal warping to occur at least in some places, the hingeline of the longitudinal flexure so formed may, obviously, be either landward (H_1) or seaward (H_2) of the pre-existing shoreline (Fig. 7). This tends to reduce the importance of the distinction between emergent and submergent coasts, not for purposes of geographical classification, but as regards interpretation of regional geological history in comparatively recent times. Flexure on a hingeline to seaward will cause upheaval at the shoreline; whereas flexure on a hingeline situated landward will depress the shore zone. A coast already diversified with bights separated by promontories is likely to be upheaved in the bights and depressed toward the ends of the promontories, if the hingeline is between these zones. King (1951, p. 190) claims to recognize continental marginal warping in South Africa, where commonly the hingeline has been out at sea, and the coast has therefore risen; but some parts of the coast are intersected by drowned valleys, which King regards as indications of an inland sweep of the hingeline, causing local submergence.

Coastal Categories in the Classification Proposed by Cotton (1918)

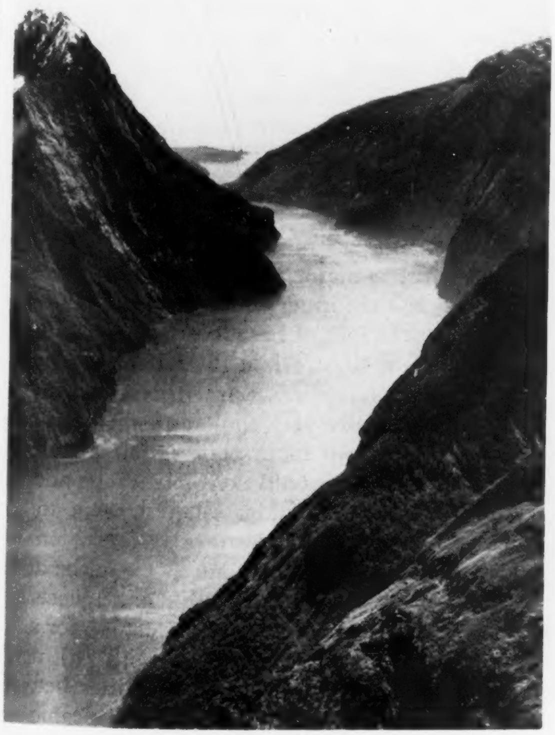
Besides emergent and submergent coasts (both attributable to either marginal flexure of the land or regional change of relative level of sea and land). Cotton's classification (1918, p. 326) recognized additional classes which Johnson would place in the "neutral" group. These were coasts produced by (*a*) volcanic accumulation; (*b*) faulting* (Photographs 4 and 8); and (*c*) glacial overdeepening below sea level (Photograph 6).

* Closely related to fault coasts in origin, and best placed with them in a single "tectonic" major category, are those initiated by *sharp* monoclinal flexure, as recognized in theory (and termed "fold coast") by Shepard (1948, p. 71). There is remarkable development of outline thus initiated in a middle segment of the west coast of the South Island of New Zealand (Fig. 1), where the trend conforms strictly for long stretches to the strike of young strata which dip seaward at about sixty degrees (Healy, 1938; Wellman and Willett, 1942; Wellman 1951). Quite possibly this coastal monocline, rather than the "Alpine" fault (Wellman and Willett, 1942, Plate 48), which runs inland northeastward is the continuation of the great coastal fault bounding Fiordland (Fig. 1, locality 4). This *monoclinal* type recurs near the northern end of the west coast, north of Karamea River (Photograph 5).

Fault Coasts and Compound Coasts. It was already on record (Cotton, 1916) that there are coasts of fault origin (and undoubtedly there are some of monoclinal origin also) that were initiated at a date earlier than that of the current marine cycle. Some of them have been subsequently upheaved (or the sea has receded from them) so that they have become also coasts of emergence (Photograph 7); others have become partly submerged. In either case their place is now strictly in the "compound" category, as Johnson (1919, p. 400) has recognized.

On the other hand, extensively developed tectonic coasts (fault or monoclinal) that are still in their first cycle cannot be common, for the obvious reason that there has been little time for the formation of great faults or flexures since the last oscillation of ocean level. Nevertheless, there are some such coasts (Photograph 8); and the deductive theory of the development of fault coasts is of value not only for interpretation of these but also for the study of coasts of remote fault origin.

In his "compound" category Johnson (1919, p. 401) included a combination of fault coast and coast of submergence which, it might be deduced, would result from complete submergence of an off-



PHOTOGRAPH 6. Fiord-wall shorelines, Milford Sound (N. Z.). (By V. C. Browne.)

PHOTOGRAPH 7. Emergent, or "multicycle", coast, very probably a fault coast of an earlier cycle, Tongue Point, near Wellington (N. Z.). (From N. Z. Ministry of Works.)

shore block separated by a fault from land that is partly submerged as a result of its having subsided at the same time as the offshore block (Cotton, 1916, Fig. 4: Johnson, 1919, Fig. 124). Thus valleys are drowned, while the outer shore is defined by an interrupted fault scarp. Though no well-preserved example of a coast resembling that figured has been described in detail, a west-facing fault-bounded coast at Thames (N.Z.) is succeeded northward by that of the embayed northern end of Coromandel Peninsula so as to introduce the compound type in the transition area (Fig. 8A). The peninsula is generally regarded as a large faulted earth-block with endwise tilt northward, in which direction it tapers to a point and its high axial range appears to plunge. Deep submergence of a land surface is there indicated by the presence of outlying islands, but such coastal evidence of submergence is overlaid by a redrowning of the shores due to regional positive movement of ocean level, probably eustatic and postglacial, which is conspicuous around the whole northern end of the North Island.

"Multicycle" Fault Coasts. The diagnosis of a fault coast is not necessarily a claim for such origin within the current cycle, that is, since the postglacial rise of ocean level. That fault coast in particular which outlines the vast sweeping curve of the outer border of Fiordland, in southwestern New Zealand (Photograph 4), cannot be of such recent development. If, however, such outlines originated as tectonic scarps in an earlier though possibly rather remote cycle, they are still fault coasts, though in the compound category also. Parts of some of them are recognizable as fault coasts in a second, or later, cycle because now bordered by marine terraces indicative of considerable emer-

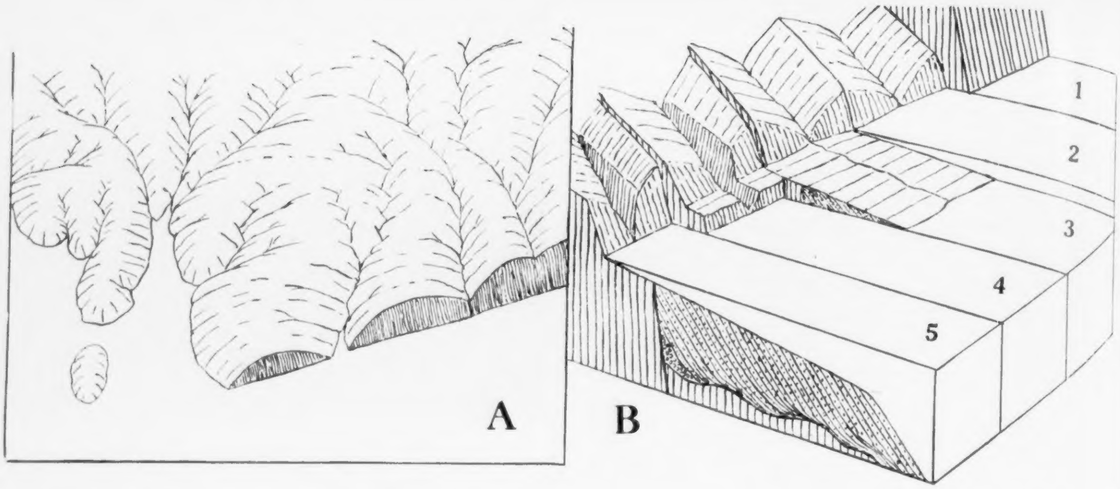


FIG. 8. A. A fault-scarp bounds a tilted block of country (right), as at Thames (N. Z.), while there is a submergent coastal outline on the plunging end of the block (left), as on the north end of Coromandel Peninsula (after Cotton, 1916). B. A "two-cycle" fault coast. Stages of development are numbered 1–5 (after Cotton, 1916).

gence since the (remote) faulting period* (Fig. 8B and Photograph 7).

Coasts of Transverse Deformation. In 1942 (Cotton, 1942a, b; see also 1951a) a further addition was made to the main classes of Cotton's classification of 1918, namely, coasts of "transverse deformation," which revived Gulliver's category of "diverse movement." Since flexure on a hingeline parallel to a coast is called longitudinal, the description "transverse" is applicable to deformation more or less at right angles to this. Either dislocation or strong warping on such lines can bring together side by side contrasting coastal types showing features characteristic of emergence and submergence, associated also in some cases with stretches of fault coast (Photograph 8). The combination and juxtaposition of these affect the general aspect of a coastal province, and in addition the deformation causes large-scale sinuosity or zigzag development of outline by producing major salients separated by embayments of tectonic origin, examples of which are prominent features of the coast around the southern end of the North Island of New Zealand (Photograph 8). These features are generally much larger than are most embayments and headlands due to marginal drowning of dissected land.

Coasts of Stable and Mobile Regions Contrasted

It has recently been suggested (Cotton, 1952b, p. 15) that the distinction between emergent and submergent coasts, though still important, might perhaps be relegated to secondary rank by recognizing as a new basis of primary classification a dichotomy of coasts of stable and of mobile regions, the latter being exemplified in the still-writhing parts of the mobile belts of the world in which are seen the effects of diastrophism that has been active within the last few thousand years. For full implementation of such classification there is as yet insufficient information on record regarding the geomorphology of the mobile regions. Even their coasts, relatively accessible as they are, have received insufficient attention; but there are certainly features indicating recent emergence of parts of the coasts of New Zealand, California, Japan, Persia, and South America.

If differentiation of stable and mobile regions ever becomes a major line of division for coastal classification, the former will be seen to have experienced only changes of base level due to oscillation of the ocean surface, while the latter have moved up or down or have been warped. Notwithstanding this, coasts initially very similar might be formed in each of the two main classes; but a different basis of subdivision could conveniently be adopted for each. In those regions where, owing to one cause or another, upheaval or deformation has taken place in postglacial time, it would be advisable to subdivide into coasts of submergence and emergence, with provision also, of course, for additional classes, for example, those with (*a*) newly made fault (or monoclinal) boundaries between land and sea, and (*b*) constructional (volcanic and sedimentary-depositional) outlines.

In the case of stable regions, on the other hand,

* This description does not imply such renewal of faulting on the line of the primitive coast, when a second upheaval has taken place, as is shown in a textbook illustration by Lobeck (1939, p. 354, B), which misinterprets the geological history of the type (compare Fig. 8B).

clearly all the coasts, with the exception of growing delta margins, outbuilding sandy coasts, and new volcanic forms, must show a drowned outline due to the postglacial rise of ocean level. Even here, however, a dichotomy based on recognition of features due to emergence and submergence may prove to be the most satisfactory for subdivision. Owing to locally slow tempo of change of land form due to subaerial or marine erosion some coasts may still be dominated by features characteristic of emergence, in spite of the fact that there is evidence of a more recent drowning of their outlines.

It is obvious that nearly every coast can be described as "compound," as defined by Johnson; but, because this category is so omnivorous, it is of little real use for purposes of classification. It might, therefore, be divided into classes as follows:

A. *Coasts of stable regions.* All drowned in the most recent submergence (though all in reality compound): (1) dominated by features due to the most recent submergence; (2) dominated by features resulting from some earlier emergence; (3) miscellaneous (volcanic, fiord-wall, etc.) coasts.

B. *Coasts of mobile regions.* All compound but affected by diastrophic as well as eustatic changes of base level: (1) coasts on which the most recent movement of base level, however caused, has resulted in submergence; (2) coasts on which the most recent diastrophic movements have resulted in emergence; (3) fault and monoclinal coasts; (4) miscellaneous (volcanic, fiord-wall, etc.) coasts.

PHOTOGRAPH 8. First-cycle fault coast at Wellington (N. Z.) as seen from above. Beyond it is the Port Nicholson embayment, occupying a tectonic basin recently submerged by transverse deformation affecting the southern end of the North Island. (From N. Z. Ministry of Works.)

Whether this suggestion is practically applicable or not it has at least the merit of re-emphasizing the importance of the distinction between emergent and submergent coasts, which "with their contrasted morphology and development have a very real existence" (Wooldridge and Morgan, 1937, p. 358).

Primary Classification on the Basis of Sequential Development

Genetic classification begins almost necessarily with the initial forms of coasts; but most coasts as

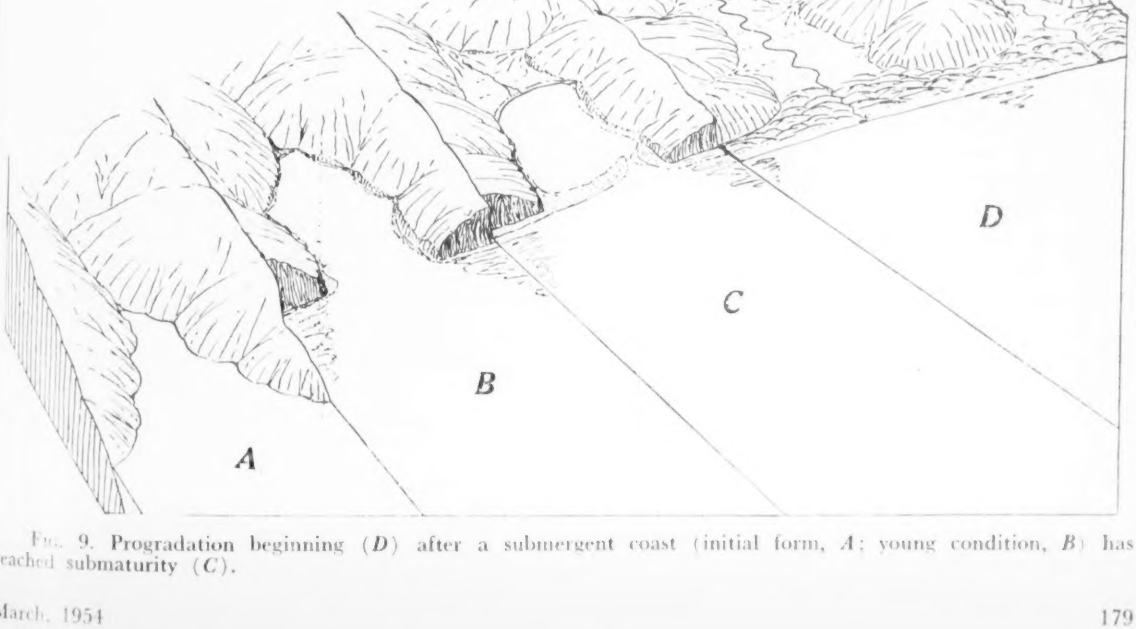


FIG. 9. Progradation beginning (*D*) after a submergent coast (initial form, *A*; young condition, *B*) has reached submaturity (*C*).

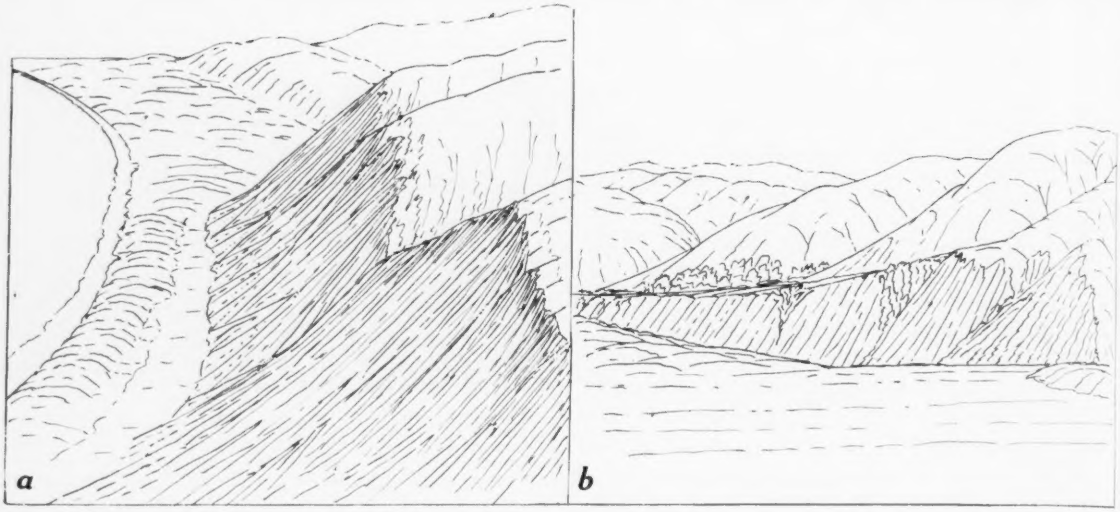


FIG. 10. Prograded coast at Paekakariki, Cook Strait (N. Z.) *a.* Progradation is extending southwestward along the base of high, fresh wave-cut cliffs, thus fending off the sea so as to prevent further cliffing. *b.* Evidence of oscillation between cliff-cutting and progradation. Fans have been built out over a foreland; these are truncated by sea cliffs that are still fresh; and the sea has again been forced back from the line of cliff by renewed progradation (northeast of locality 3, Fig. 1).

we find them have been transformed into highly developed sequential coasts in the course of the marine cycle. So complete may be the metamorphosis that it may now be well-nigh impossible to form a reliable opinion as to the nature of the initial coast and its origin. Complications may be introduced by:

1. *Tempo of development.* One coast may run through a cycle of changes a thousand times as rapidly as another, even though on such coasts the dominant process is erosion little complicated by the effects of accumulation.

2. *Convergence of development.* Very similar coastal forms and assemblages may have very different histories. When developed to full maturity coasts of emergence and of submergence, fault coasts, monoclinal coasts, and perhaps others can become indistinguishable from one another, though this presupposes a very fast erosional tempo in the case of some coasts.

3. *Progradational development.* While variation of tempo of erosion might offer a convenient method of subdividing main classes of coasts, progradation, with the transformation it can produce, seems to offer greater possibilities.

Coast Affected by a Progradational Accident. A progradational accident (Cotton, 1951b), that is, a change from coastal erosion to outbuilding, generally by the piling up of a succession of beaches, may supervene at almost any stage of the erosional development of a coast. In the case of a cyclically developing coast of submergence, however, the stage of youth must be past, bays being by this time bridged by barriers of the bay-bar variety, so that there is already in existence a continuous beach along the shore. Here must be noted another enormous contrast in tempo of development, namely, that between the case in which all the gravel or sand for potential beach-building (and spit- and bar-building (must be produced in place by local erosion of cliffs, especially if these are composed of hard rock, and that in which, independently of local rock hardness and of the local tempo of coast erosion, such materials are supplied in abundance by drift alongshore from some more distant source, usually the mouth of a large river.

When, however, in a few centuries or in tens or hundreds of thousands of years, cliff erosion is superseded by coastal accumulation (Figs. 9, 10), as it must be, eventually almost everywhere if stillstand continues long enough, the shoreline advances and beach after beach is built along the front of a flat or dune-covered foreland (strand plain) of growing width, so that the character of the coast soon becomes entirely changed. A similar result may be produced by alluvial accumulation—the growth of a large delta or a fringe of smaller confluent deltas—in front of a former shore.*

* The varied character of the coasts of the present day is due very largely to the instability of levels, including that of the ocean surface, in recent geological time. In the long-past ages of great stability of base level in which extensive peneplanation of lands took place, low prograded coasts must have been monotonously prevalent, except in those regions then affected by diastrophism, if there were any such regions.

Yet another major dichotomy is thus indicated, for an important line must be drawn, perhaps the most important of all for geographical purposes, between those coasts which are more or less continuously prograded and those which are not (compare Shepard, 1948, pp. 73–74). Such distinction may be made either between primary categories of coasts or at a lower level. If the genesis of coasts as a whole, or of coastal outlines, is the object of study and must therefore be given first place in the classification adopted, the separation of coasts dominated by erosion and accumulation, respectively, may be useful only as of minor subdivisional rank. Thus, all the categories of coast, originating in every imaginable way, may be made to branch into a final trichotomy: (1) retrograded (eroded); (2*a*) prograded by alluviation (delta-fringed); (2*b*) prograded by beach-building (fringed by strand plains) (Cotton, 1918).

If, on the other hand, a classification for purely geographical purposes is aimed at, it may be established on this primary basis, thus:

A. Coasts undergoing erosion (cliffed coasts).

B. Prograded coasts, with progradation commonly still in progress.

The contents of the classes thus defined would be roughly the same as of the empirical but geographically useful categories steep or high and flat or low coasts.

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The Social Versus the Physical Effects from Nuclear Bombing*

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Physical Predictions and Social Predictions

A FEW years ago, at the time this country had to decide whether it should attempt building a hydrogen bomb, the newspapers published maps which showed the radius of destruction from a hydrogen explosion superimposed on the New York metropolitan region. These horrifying circles, which cut out most of New York and its suburbs, were based on calculations that nuclear physicists had made without benefit of any empirical data on an actual explosion. Thus, the physical effects could be discussed before the development of thermonuclear weapons ever began. But more important than the physical effects of bombing are the social effects, which cannot be estimated with the same accuracy. For a war, physical destruction in cities is decisive in so far as it affects the urban economy, industrial production, and the government's will and capacity to continue fighting. Moreover, nuclear bombing could also have a grave impact upon the future of society; it might stifle art, science, and religion, and perhaps jeopardize our whole civilization.

In contrast to the physical effects, the possible social effects of nuclear bombing in cities are particularly difficult to estimate as there exists no empirical evidence except for the explosions in Hiroshima and Nagasaki. These two explosions were due to single atomic bombs much less destructive than more modern weapons. Furthermore, the explosions occurred at the end of a war and therefore shed little light on their effect upon a continued war effort.

Despite this difficulty of predicting by analogy, it is nevertheless possible to arrive at some predictive estimates. A city can be understood as a complex of interrelated functions combining both physical and social components. For purposes of analysis this functional interdependence can be broken down into various homogeneous relationships between social and physical factors. A relationship is functionally homogeneous if it basically serves only one function in the city. For example, housing as the relationship between dwellings and dwellers is functionally homogeneous because it chiefly serves only the one function of accommodating the city's inhabitants. From these physical-social relationships we can derive generalizations and regularities showing how the city's social functions are affected by different degrees of destruction. Thus we discover trends that can be extrapolated beyond the range of our empirical data to obtain estimates about the social effects of nuclear destruction.

"Elasticity" of Physical-Social Relationships in a City

A basic principle which emerges from this analysis of the city according to different functions is the "elasticity" of physical-social relationships. A city is capable of making adjustments to physical destruction much as a living organism responds to injury. If a section of a city is destroyed, the effect is not as if this section were merely lopped off. The undestroyed sections can compensate for the functions previously fulfilled by the destroyed part. In an emergency situation a city's physical components

* Based on the forthcoming book by this author, *The Social Effects of Bombing in Cities*. The research for it was carried out at the Population Division of the Bureau of Applied Social Research, Columbia University, and was supported by the U.S. Air Force under Contract No. AF 33 (038)-14313, monitored by Human Resources Research Institute, Maxwell Air Force Base, Alabama.

can be utilized much more intensively than under normal conditions, hence a certain amount of physical destruction does not lead to an equivalent loss in social functions. For example, if fifty percent of a city's houses are destroyed, it might still be possible to accommodate the entire population through doubling-up in the intact dwellings. Similarly, a partial loss of transit facilities can be absorbed by crowding more passengers into the remaining vehicles.

This elasticity of the various relationships in a city is important. Up to a point it tends to make the social effects of bombing smaller than the physical effects. It is erroneous to assume that the socio-economic loss due to bombing would be equal to the socio-economic content of the area destroyed. This kind of reasoning has led to the misleading phrase of "wiped-out" cities. Not all the people and economic functions in an area that has been destroyed would be removed from the war potential.

Data from World War II show that the population loss in a city was generally much smaller than its housing loss, and furthermore, the decline of the industrial labor force was proportionally smaller than the loss in total population. The relationships between housing and population, and between total population and labor force, are elastic. For example, the city of Hamburg lost almost fifty percent of its dwellings during the raids in 1943, but within three months it had recovered two-thirds of its population, and manpower in certain war industries showed no loss at all.* In most German and Japanese cities population loss was proportionally smaller than housing loss as soon as the imminent threat of air raids discontinued. Statistical comparison of the Japanese and German situation shows, however, that less doubling-up took place in Japan. Consequently the population loss in Japan was greater for the same amount of physical destruction.†

The Disproportionately Larger Effects of Increasing Destruction

As nuclear weapons could cause much greater destruction than the bombings of World War II, it is crucial to know whether an increase in physical destruction leads to a proportionate increase in social effects. We must be careful in drawing conclusions about nuclear bombings from our knowledge of World War II bombings because the magnitudes involved are different.‡ Increasing destruction leaves an ever smaller amount of physical facilities that can absorb the damage. After physical destruction exceeds a certain percentage of the city's total resources a further increase in destruction will result in a disproportionately larger increase in social effects. The elasticity of physical facilities will be exhausted and a further increment of destruction must have a greater social effect than the same increment would have if the total amount of destruction were lower.

The basic principle of this process is simple. It can be exemplified with housing, but it applies also to the other physical components of the city and their corresponding social functions, such as transportation, food distribution, and communications. Let us assume that the average housing density in a city can increase to a maximum twice the predestruction number of persons per dwelling unit. After housing density has doubled, a bombed-out person, on the average, would rather leave the city than crowd into the remaining homes. Thus, there need not be a population loss up to fifty percent destruction except for the casualties, because fifty percent of the dwellings can still accommodate all the population. But if eighty percent of all dwellings are destroyed, the remaining twenty percent could accommodate only forty percent of the population.

For Fig. 1 we have calculated a hypothetical example of a city that had 5 persons per dwelling before destruction and a maximum housing density of 10 persons per dwelling after destruction. To simplify the presentation we assumed that the casualty rate per increment of physical destruction would be constant (1 casualty per dwelling destroyed) regardless of destruction size. (This is not quite correct; the number of casualties per housing unit destroyed tends to increase as destruction becomes larger.) We made the further simplification that all homeless survivors would seek reaccommodation within their city, provided housing density does not

* A similar "elasticity" can be documented for many other cities. It applies to the relationship between physical transit facilities and commutation of workers, as well as to other relations between a city's physical and social components. The data for these analyses came from the *U.S. Strategic Bombing Survey,* Washington: G.P.O. (1946–47), 316 reports, and the unpublished records to these reports; furthermore, from municipal documents and statistics about the wartime, and from special postwar surveys or censuses.

† Presented in detail in the forthcoming book quoted in the footnote at the beginning of this article.

‡ The difficulty of estimating the social effects of nuclear destruction from World War II findings must be kept in mind if we utilize the *U.S. Strategic Bombing Survey,* including the reports about Hiroshima and Nagasaki. These reports in combination with additional data from municipal authorities are of greatest value for an analysis of the "elasticity" between physical and social destruction effects. Once we know better how to relate the physical effects to the social effects we can then utilize the exclusively physical estimates of nuclear destruction, such as Los Alamos Scientific Laboratory, *The Effects of Atomic Weapons,* Washington: G.P.O. (1950).

exceed the given maximum. Actually, only a certain portion of the homeless survivors find reaccommodation within the city; the rest prefer to remain in evacuation.

Figure 1 shows that population loss is not a linear function of destruction. There are two different stages in this curve. In the first stage the social effects increase more slowly than physical destruction; in the second, they increase faster. Whether the first or the second stage will result from a certain explosion does not depend on the absolute size of destruction. The larger a city, the greater destruction has to be in order to induce the second stage. Thus, the prevailing belief that the largest cities are the most vulnerable ones is erroneous.

The great threat of nuclear weapons is that they could destroy so large a portion of a city or metropolitan area as to produce social effects of the second stage. The proportion of a city's physical components left intact would be insufficient to cushion the loss in destroyed areas. The effects of the explosion, therefore, would spill over into a large region surrounding the bombed city. The homeless would have to seek accommodations in other cities, towns, and villages.

However, if the evacuated workers could be employed in undestroyed cities and towns, it might be possible to reduce the production loss suffered in the destroyed city. We found that the elasticity of physical facilities in undestroyed parts of a bombed city permitted social readjustments to conventional bombing. To some extent a similar mechanism would allow for adjustments to nuclear bombing on a nation-wide scale. Nuclear destruction in a number of large cities would not mean the end of urban society in that nation. The city dwellers who survived would continue to live as urbanites, although perhaps temporarily removed from their former habitat. They would have to find employment and shelter in the towns and villages that would be left in the country. The principle is again the same as for the intra-city rehabilitation in case of conventional bombing: the more physical facilities that are left in a country the better the damage can be absorbed.

The situation that would develop in a country after many of its large cities had been devastated by atomic or hydrogen bombs is difficult to visualize. We can perhaps derive some estimated figures and trends, but these figures leave no image in our mind, much as the figures in astronomy which bear only a numerical relationship to sizes we can perceive. Vivid accounts have been given of a few individual experiences immediately after the atomic explosions in Japan.[1]

We can take these descriptions as a starting point and try to weave the isolated individual experiences into a larger pattern describing the reactions and adjustments of a whole nation that has suffered nuclear attacks. The guiding principle is first to estimate what is left in a country in the way of physical resources and facilities and to relate this to the needs and capabilities of the surviving urban population. Some of the survivors from the disaster will return to their city, others will remain in evacuation. The ones who return will find a largely devastated city and live with greatly reduced physical facilities. They will dwell in congested housing, commute in crowded vehicles, queue for food, eat in emergency cafeterias, and perhaps live without water except for a communal emergency supply.

Those who stay in evacuation will be billeted in private houses, hotels, or emergency dormitories. Food, clothing, and all other consumption goods will be short in reception areas since the population suddenly increased and because many evacuees arrived destitute. Social friction will arise between the evacuees and the population in reception towns because of ethnic, religious, and class differences. The friction is likely to increase with time and might drive many evacuees back to the partly devastated cities. World War II data shed much light on these social problems of evacuation.[2]

We cannot assume that nuclear warfare would be limited to single bombings of particular cities.* Further attacks on a given target will impel another mass exodus from the already devastated city. After such a second attack the majority of the population will probably leave the city, motivated by new casualties, the vast destruction, and the continuing air-raids alerts which emphasize the threat of still more bombings.† Besides, the physical facilities, especially housing, will be so diminished that the city could not accommodate more inhabitants despite a maximum utilization of what is left. Nearby reception areas, already crowded to capacity from the first attack, will be unable to accommodate the new influx. Evacuees will have to trek on in search of

* The present planning and thinking on civil defense is largely confined to the problem of one single attack—usually conceived as a sneak attack. Although the idea of a sneak attack is most frightening and particularly difficult to plan for it should not divert us from making feasible arrangements to cope with the problem of repeated nuclear attacks. The special issue of the *Bulletin of Atomic Scientists* (Vol. IX, No. 7, Sept. 1953) on "Project East River—The Strategy of Civil Defense" makes only occasional reference to the possibility of repeated attacks and to evacuation as a long-range problem (Roland Sawyer's and Dwight W. Chapman's contributions mention long-term aspects).

† The effect of repeated attacks upon population flight is well illustrated by the successive big raids in Hamburg

lter and food, gradually spreading over the coun-side and colliding with the flow of refugees from her devastated cities. Friction and competition for e diminishing resources of existence are bound to cur. The daily need for food will be the major oblem. Population statistics from World War II mbings show that under conditions of great stress e movements of city dwellers are dictated pri-arily by the availability of food. Consequently, a ll-organized food reserve and an efficiently anned rationing system would be the most effec-e means for a government to control and re-bilitate the urban population.

It is wrong to argue that the population could t endure such trying experiences and would not willing to cooperate with the government in con-uing the war effort. It would not be so much a estion of fortitude but rather the fact that no ternatives are left. Desertion is out of the question cause there will be no place to go. The urban fugees will soon discover that villages, towns, and all cities are the best places to live in; much more mfortable and socially more satisfactory than aves," distant summer cottages, and other such treats that might come to a person's mind after e first bombing experience. Besides, the evacuees ill have to earn a living and only a few can secure bs on farms; the rest must work primarily in de-nse jobs. The surviving urbanites can neither live the devastated target cities, which may still be dioactive and where life is constantly endangered future attacks, nor in the barren rural country, ithout housing, without jobs, and most important, ithout the social environment to which they are ccustomed. The only places for them will be vil-ges, towns, and unattacked cities. The numerical rength and pressing needs of the refugees will be o overwhelming as to overcome the natives' resist-nce and force them to share their homes, their itchens, and their household goods. Thus, the mall town inhabitants engulfed in the depriva-ons and distress of the evacuees will fare little etter than the survivors from devastated cities.

High Casualties

The most serious aspect of nuclear bombing is he large number of casualties. Casualties have a wofold effect upon the social and economic life of city. First, there is what we may call "demo-raphic effects": the number injured or killed neans a loss in population and labor force, and the are of the injured and disposal of the dead will ivert manpower. The second effect is more psy-chological; the behavior of the surviving popula-tion can be overwhelmingly affected through the

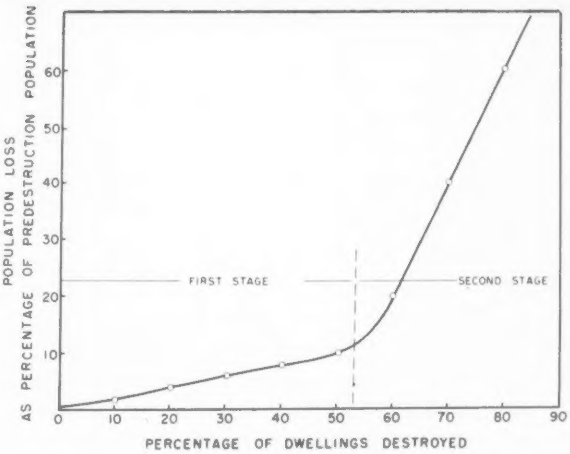

FIG. 1. The disproportionately larger population loss of a city resulting from increasing housing destruction.

emotional and morale impact of casualties. Compared with conventional bombing, the atomic bomb aggravates these emotional disturbances. It leads not only to a larger number of casualties but also to injuries that distort the appearance of victims and have a powerful effect upon those who see them.[3]

It is possible to estimate the demographic effects of casualties from nuclear bombing by combining the figures on physical effects with those on population densities in cities. The emotional and morale effects of casualties, however, are more difficult to predict. The experience of Hiroshima and Nagasaki give no indication as to what a continued threat of death and bodily injury might do to a city's population. Perhaps the plague epidemics in the Middle Ages provide a better example for continued exposure to a great risk of death, emphasized by the daily perception of casualties. London lost about one-sixth of its population because of the plague epidemic in 1603, proportionately a higher death toll than that suffered in Hiroshima by the atomic bomb. Yet London was able to recover quickly and resume its functions as the nation's leading city. Mass flight, however, occurred at that time; it was checked only by the refusal of the Lord Mayor to grant further certificates of health, and by the effective opposition of the neighboring townships, which in self-defense set armed guards upon their roads.[4] This provides a remarkable parallel to the Departure Certificates in Hamburg some 300 years later, which were introduced after the heavy air raids in order to control the population flight.

But the ties which bind urbanites to their city are so strong that even a continued danger of death need not lead to a complete abandonment of the city. The important criterion is whether the risk of

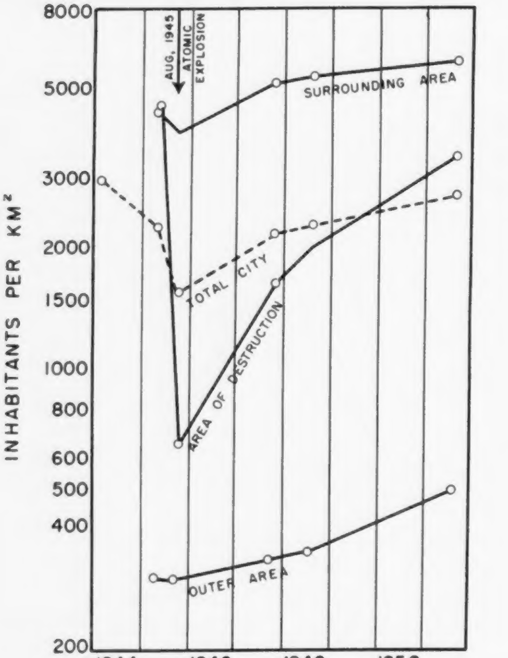

FIG. 2. Density trends in Nagasaki 1944–51, for areas and for total city.

death or personal injury is sustained and apparent for the inhabitants. If the people at large do not fully realize the threat, they are not likely to abandon their city for any length of time. This is exemplified by the premature return of evacuees after a temporary respite from air raids, often in defiance of governmental instructions.

The Long-Range Effects

At the end of World War II numerous writers assumed that destruction would enhance decongestion and planned improvements in cities. The literature on city planning right after World War II abounds with such optimistic predictions.[5] Yet, the obstacles to city planning lay not so much in the tearing down phase but in the great cost of new construction. A war-damaged country is not in a position to meet such costs, yet returning evacuees cause a pressing need for housing, and reconstruction cannot be postponed. The cheapest and fastest way to rebuild is to utilize the old layout of streets, and to take advantage of the undestroyed underground facilities.

Evidence of the lack of radical changes in the postwar reconstruction can be found for most cities damaged during World War II. For the city of Nagasaki we grouped the districts according to their proximity to the atomic explosion (Fig. 2). (The "surrounding area" largely escaped destruction but is still urban in character with high density; the "outer area" comprises suburban districts.) As expected, the "outer area" has a higher density after the explosion. The most important finding, however, is the rapid density increase in the "area of destruction." If we extrapolate this trend we find that some time between 1955 and 1960 the predestruction density will have been recovered. In other words, the effect of the atomic bomb in Nagasaki upon the spatial distribution of the population within the city will have disappeared some ten years after the explosion.

The question has been raised whether large disasters from nuclear bombings might cause psychological disturbances that could lead to lasting impairments for many city dwellers. There is no evidence from World War II of lasting psychological impairments from air raids. The few instances of psychiatric casualties were scarcely more frequent than such psychiatric disturbances in peacetime. Nuclear bombings would affect a greater number of people physically and psychologically, but there is no reason to assume that the psychological effects would be basically different, except for the stronger emotional impact from casualties mentioned above. Family life would be seriously affected during air raids because of the destruction of homes and the separation of evacuated children from their parents. Many children would grow up in a different environment and receive a somewhat different education. However, the strong tendency of parents to reunite with their children, as shown by the evidence from World War II, indicates that this temporary disturbance cannot destroy the prevailing pattern of family life.

We should not expect fanciful and obscure effects from nuclear bombing. If there are such effects, they are likely to be completely overshadowed by the simple pedestrian difficulties of poverty and overcrowding. To find an additional mattress or cooking pot, to locate some glass for replacing a cardboard window pane, or to eke out the food ration by tilling a victory garden will be more important for most surviving city dwellers than an increase in juvenile delinquency, psychological bombing traumas, or localized areas of radioactivity which cannot be resettled for some time.

If we try to estimate the social effects of nuclear bombing we should not be misled by the awesome physical destruction to make occult predictions about the end of civilization. There is no reason to expect large masses of city dwellers to suffer mental breakdowns, or to fear that mankind would abandon technology and science. Such prophecies are not only unscientific but actually harmful because

they lead to apathy and ignorance in the area of civil defense. The present shocking inadequacy of American civil defense can partly be traced to the editorial off-the-cuff statements regarding the alleged social effects of nuclear bombing. These statements were made with the good intention of arousing world opinion and promoting the forces of peace.* However, the ease with which doom has been predicted and the all-or-none terms into which the prophecies were cast made them seem like ghost stories, too unbelievable to initiate any action. The result is a blocked thinking among many citizens and responsible politicians. Everyone is aware that atomic bombs exist and could be delivered against our cities, but most people fail to realize the consequences of such an event and practically nothing is being done to mitigate them. Rational thinking stops at the very point of the atomic or hydrogen explosion. Up to that point we have careful planning of the production of nuclear weapons, physical research, scientific calculations, and accurate knowledge. After the explosion the uncontrolled thinking sets in; there is chaos, doom for all humanity, suicide, and immediate defeat or victory.

The first nuclear bombings would only mean the beginning of long tribulations, and each city or country afflicted would go through prolonged efforts to make adjustments, to compensate for the losses, and to heal the inflicted wound. The curve in Fig. 1 illustrates the outcome of such an adjustment process; its parameters are not fixed by physical conditions alone but depend largely on the organization for accommodating the homeless. Most of our present civil defense plans make no such provisions beyond short-range emergency shelters. With nuclear destruction, reaccommodations would have to be nation-wide, and not merely city-wide as in World War II, so that planning becomes even more important.† The recent demands for better information about the effects of nuclear weapons seem to be an effort in the wrong direction. The public knows more about the physical effects than it can cope with. It makes little difference whether a certain destruction radius is ten or fifteen miles if we cannot grasp the social implications of large-scale destruction at all. If better physical science information should only lead to more editorializing about the end of civilization and the extinction of mankind we will scarcely improve our national security. Careful estimates of the social effects of bombing can do more to relieve suffering and to reduce the peril of defeat than apocalyptic exhortations about the Dark Ages that will set in.

* Cf. for example; H. Bethe, *Bulletin of the Atomic Scientists* **6**, 99 (1950); and H. Bethe, H. Brown, F. Seitz, and L. Szilard, *Ibid.* pp. 106 and 126; criticized by J. R. Arnold, *Ibid.* p. 290.

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† The homeless would have to be billeted almost exclusively in *private* homes (enough emergency housing could not be constructed because of shortages), and the organization for reemploying evacuated workers would assume paramount importance. These tasks have scarcely been dealt with in "Project East River" or related studies on civil defense.

BOOK REVIEWS

Atomic Medicine. 2nd ed. Charles F. Behrens, Ed. Baltimore: Williams and Wilkins, 1953. xiv + 632 pp. Illus. $11.00.

THE second edition of this useful book is updated, and to some extent expanded. The twenty contributors are, with one exception, the same as for the first edition. With its clear and simple discussions of atomic physics in the early chapters, it is an excellent and readily comprehended introduction to atomic medicine. It can be recommended to the physician and to the medical student who desire to gain an understanding of the effects of ionizing radiation on human beings, and who wish at the same time to learn something of the value as well as some of the limitations inherent in the use of radioisotopes and of ionizing radiation in general in the practice of medicine and experimental biology. There is much useful material on radiation detection and on methods of achieving radiation protection in the laboratory and hospital.

The chapter on "Radiation Illness: Its Pathogenesis and Therapy," by Commander Cronkite, has been completely rewritten and is as definitive a statement of the present state of our knowledge of the subject as one could wish for. The chapter "Permissible Dosage and Risk Factors of Ionizing Radiations," by Admiral Behrens, is an especially considered and lucid statement of the problem. It is recommended reading for all persons who need to understand the basis for permissible levels of exposure in emergency situations as opposed to permissible levels arrived at on the premise that an individual will be working with radioactivity for the majority of his productive years.

Geschickter and Copeland have brought their chapters up abreast the ever-changing field of medical uses of radioisotopes, and have placed the present status of each in good perspective.

Like all multi-authored books this one is uneven. This particular edition, however, suffers more than is necessary in this respect, because of an evident laxness of editing. For example, the uses of radiogallium, radiophosphorus, and radioiodine are discussed quite adequately in chapter 18. The discussion of the same isotopes in chapter 20, "Dosimetry and Administration of Radioisotopes," could well have been omitted. Careful editing would likewise have avoided confusing the reader by contradiction on such an important matter as the genetic effects of ionizing radiation. The statements on this subject in chapter 12, "Radiation Protection," are clearly at variance with those in chapter 9, "Permissible Dosage and Risk Factors of Ionizing Radiations." Chapter 13, "Survival Methods in Atomic Disaster," is over-optimistic in places. For instance, the following occurs in a discussion of subsurface atomic explosions: "In general, however, where due regard can be and is paid to this hazard, there will probably be, *even in the most heavily contaminated areas*, sufficient time for orderly evacuation before anyone receives a dangerous dose" [emphasis supplied]. In reference to the natural reluctance of people to leave valuable and cherished possessions behind, it is stated: "The police and other authorities will keep an eye on their premises, so that these may well have as good, or better, protection than in normal times." The statement, "It is well known that in Japan there were no permanent definite after-effects of radiation in those who survived, except for cataract formation in a few instances," is no longer warranted, especially in the light of the report by Folley *et al.* which appeared in the September 1952 issue of the *American Journal of Medicine* on the incidence of leukemia in survivors of the atomic bomb in Hiroshima and Nagasaki.

By and large, however, this edition of the book is both authoritative and well written.

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The Natural History of Infectious Disease. 2nd ed. Macfarlane Burnet. New York: Cambridge University Press, 1953. x + 356 pp. Illus. $4.50.

THIS is the second edition of a book that appeared in 1940 under the title *Biological Aspects of Infectious Disease*. The present edition has been slightly expanded to include many new developments but the basic concept of the original book and its distinctive character have been well preserved in this revision.

The author, who describes himself as an immunologist, is honored throughout the scientific world as a virologist of renown. In this volume he reveals himself as a biological philosopher with a broad knowledge of vital phenomena and a keen insight into the vast struggle for survival. This volume deals with that portion of the struggle that occurs between parasitic microorganisms and their hosts, especially man.

After introductory chapters dealing with the ecological point of view and the evolutionary concept of infection and resistance, the author describes the various forms of parasites—the aggressors—and the different types of body defense mechanisms. Attention is then given to the mass phenomena of the spread and occurrence of infectious disease, a scholarly discussion of basic concepts of epidemiology. The book closes with a series of chapters devoted to seven important diseases—diphtheria, influenza, tuberculosis, plague, cholera, malaria, and yellow fever—that illustrate the principles that have been emphasized earlier in the book. There is a final speculative look into the future.

This is not a popular book that will be a best seller for the man on the street. Written for the educated reader, preferably one who has some knowledge of science, the style is simple and direct, but the concepts are not always simple. The author starts from the pre-

mise that the reader does not necessarily have any substantial biological background, but is interested in the phenomena of infections and the biologic significance of microbial parasitism.

This is a book that can be recommended without qualification as authoritative and thoughtful. It is a volume that well deserves a place in any biologic library and merits repeated reading.

GAYLORD W. ANDERSON

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Plant Diseases, the Yearbook of Agriculture, 1953. Washington, D. C.: U.S. Department of Agriculture, 1953. xviii + 940 pp. Illus. + plates in color. $2.50.

WEATHER, insects, and plant diseases are often called the worst natural hazards in farming. The 1941 and 1952 Yearbooks dealt with the first two. This book completes the triad. It is a wonderfully useful reference, not only for American farmers but for anyone else concerned with growing plants. It contains much valuable information on the causes and control of many important plant diseases. It emphasizes practical details, but also discusses fundamental biological facts.

Following a brief foreword by Secretary of Agriculture Benson, a large number of pertinent articles appear that various authorities have written. These articles about plant diseases are classified under the following general headings: Costs and Causes (14 articles), Bases of Controls (9), Growing Healthier Plants (3), Grasses and Legumes (12), Cotton (7), Food and Feed Grains (10), Vegetable Crops (18), Sugar Crops (4), The Tobacco Plant (4), Some Ornamentals (14), Fruits and Nuts (33), After Harvest (9), Some Others (10). There are 32 color plates, a glossary, and an index. Tree diseases mentioned in the 1949 Yearbook are omitted.

Prepared by so many different writers, the articles inevitably vary considerably both in style and quality, as well as in subject matter. However, each gives a relatively complete and practical discussion of one topic in clear and semipopular language.

The first article explains that losses from plant diseases amount to an estimated three billion dollars a year. Much of this is a waste that can be prevented. But the problem is explained as not being easy. New diseases and new races of well-known pathogens appear all the time. Likewise, other diseases outside our borders remain a continued threat. The efforts against plant diseases are made more difficult by the lack of information among many people who have to do with plants and plant products. This book provides much of the needed information.

Although all articles show that real progress has been made, much remains to be done. Among the most critical needs, as stated in the foreword, are steady continuous research to build up basic knowledge, and more attention to solving permanently the problems now only partially met with palliatives.

The editor (Alfred Stefferud) and the Yearbook committee (Curtis May, chairman) had a serious setback when they were forced, at the proofreading stage, to omit many valuable articles and to eliminate much illustrative material. While the resulting deficiencies are apparent, they are doubtless conspicuous primarily to those familiar with what-might-have-been. This current Yearbook will help American agriculture greatly in its effort toward ample food for all, efficient farm production and management, prosperity for farmers, sound agricultural programs, and improved understanding.

A. J. RIKER

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Sex and the Nature of Things. N. J. Berrill. New York: Dodd, Mead, 1953. xiii + 256 pp. Illus. $3.50.

THE central theme of *Sex and the Nature of Things* is animate reproduction in the broadest terms of biological significance. It is sure to prove delightful to the lay reader to whom it is addressed; it will give him new and original insight into one of the biological functions in which most of us admit intense interest. But the professional as well as the lay reader will benefit by the ease, fluency, and sensitivity with which the author has fulfilled the much more difficult accomplishment of providing an appreciation of the lives and behaviors of a variety of organisms, in their own right, at their own level, and for their own sakes. Not every natural historian has Berrill's gift of sympathy, few have his talent of lucid exposition. His combination of talents renders him one of the most successful of the popular writers.

The book is written with freshness and humor, in a style and a mood reminiscent of the fairy tales that once transported our minds into imaginary lands of new and undreamed wonders. But since the imagination of nature transcends that of man, the miracles that form the burden of Berrill's tale carry us into a realm of marvels that are all the more wonderful by virtue of their reality. The title hardly does justice to the content of the book, which is an illuminating and vivid commentary on the nature of animate nature itself. It is pleasingly illustrated by the author; and it is an important book because it is a good one.

JANE OPPENHEIMER

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Bryn Mawr College

How to Know the Spiders. B. J. Kaston and Elizabeth Kaston. Dubuque, Iowa: Wm. C. Brown, 1953. vi + 220 pp. Illus. $2.25, paper; $3.00, cloth.

IT is a pleasure to note the appearance of this most recent addition to the Pictured-Key Nature Series. Neither Dr. nor Mrs. Kaston needs any introduction to araneologists or to others informed about the general biology of spiders. This husband and wife team has been well known, especially since the appearance of that excellent work *Spiders of Connecticut.* Dr. Kaston has long been known as a keen student of spiders and his

wife has established an excellent reputation through her ability to provide clear, accurate, and attractive figures to accompany and elucidate descriptions of anatomy and activities of these interesting animals. *How to Know the Spiders* includes treatment of forty families with one hundred and ninety genera and two hundred and seventy-one species. Although the book consists primarily of a series of keys for the identification of these taxonomic categories, there is also a surprising amount of information included.

The cartoons will add interest for beginners and will be pleasing to most users of the book. The keys appear to the reviewer to be skillfully constructed with a minimum number of errors and obscurities. As an example of the infrequent errors the following may be cited: on page 188 the statement is made that the posterior row of eyes in Eustala is slightly procurved when in fact this row is distinctly recurved as correctly shown in the accompanying drawing. This error is a carry-over from a similar statement by the author in *Spiders of Connecticut*, page 226.

Further advice to beginners regarding microscopic equipment and use could well have been given but this area has been well covered in general. It is my judgment that the book should be a source of pride and satisfaction to the author and his wife. It should also be a pleasure to use and a source of much needed information and guidance to all who are trying to gain a start in the study of this much neglected and misunderstood group of animals.

A. M. CHICKERING

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Reptiles and Amphibians. Herbert S. Zim and Hobart M. Smith. New York: Simon and Schuster, 1953. 157 pp. Illus. $1.50.

THIS is a delightfully illustrated volume for the layman. For so small a volume a remarkable coverage of representative species has been achieved. The numerous illustrations give an amazing amount of information beyond merely form and color of the various animals. Even if the script is not read, the casual browser will have his interest aroused and will learn a great deal in the meanwhile. With one outstanding exception, the illustrations are remarkable for their accuracy. That of the Gila Monster reminds one of the very old picture post cards. It is regrettable that this one unusual lizard should not have received greater care in its portrayal. Since it is the only poisonous lizard, a simple portrayal of its venom transferring apparatus should have been in order. One other weakness is the omission of scientific names of the various species. These could have very readily been inserted and would have served as a connecting link for the layman who wishes to extend his knowledge into more advanced works, and would have likewise helped to popularize scientific names. As it is, it remains a carefully compiled picture book. As such, however, it should help to develop in the layman a greater interest in reptiles and a desire to protect them.

HERBERT L. STAHNKE

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Theoretical Anthropology. David Bidney. New York: Columbia University Press, 1953. xii + 506 pp. $8.50.

THIS is a scholar's book which should also prove both interesting and rewarding to the common reader, for the questions with which it deals underlie any intelligent reflection concerning matters of such varied and general interest as the significance of styles in art and literature and their changes, the rationale of political and moral principles, the formation of personality and its variation among different peoples, and the nature and limitations of scientific explanation.

It was barely a hundred years ago that the systematic analysis and comparative study of the differing ways of life and outlooks of the peoples of the world began to be developed as a branch of anthropology, and the basic concept of culture as a distinctive and crucial dimension of human life was explicitly formulated. During the century of its development, so far, there has been continuous recognition in anthropology of the need for an adequate theoretical framework within which to tackle cultural problems and to determine the relation of this specifically human modification of behavior and mentality to biological, psychological, and other natural processes. As always in the development of thought, there have been swings of opinion between extreme and conflicting views and it is one of the great merits of David Bidney's book that he brings out the contexts in which partial views came to be formulated—generally in reaction to earlier and equally partial interpretations either within anthropology or in the cognate fields of psychology and sociology—and the measure of truth or utility that they retain.

This book then is an exciting account of an adventure in ideas which is still in progress. It shows how, through the laborious study of the crafts, art, beliefs, and patterns of social relations among many different and, to the layman, often insignificant peoples and the continuous discussion of principles formulated to account for these, cultural anthropology has been moving toward a consistent body of theory concerning the nature and role of culture in human affairs. On the one hand, the fallacy of attempting to reduce the distinctive features of any particular cultural pattern to general biological or psychological principles resides, as is shown, in the fact that such a pattern is a specific adaptation or reaction to a particular and complex environment and history, all the factors in which affect the cultural outcome. At the same time, the reification of culture as an entity outside and beyond the body of people who manifest it leads to the equally false view that men are automata in the grip of an impersonal cultural process. The term culture properly refers to that

cifically human modification of behavior whereby borate patterns of purposive activity and conceptualtion can be built up, taught, learned, and so transted from person to person, group to group, and gention to generation. Cultures are continually and tly varying in their particular features in response the ever-changing physical and biological conditions men and their environments. This patterning of beior is an emergent phenomenon made possible by e evolutionary development in *Homo sapiens* of a iquely complex central nervous system on which deds man's capacity for creating and using symbols d self-consciously apprehending meanings.

Being a moral philosopher as well as an anthropolot, the author is also concerned with ultimate and taphysical beliefs on the nature of man. His proper ess on the point that men are themselves the origitors of the cultures they manifest leads him beyond e sphere of strictly anthropological judgment to ast that man is "the self-determined creator and effint cause of his cultural conditions" and that "there an irreducible distinction in kind between the mental nctions of man, on the one hand, and that of the imal kingdom on the other." It is doubtful whether colleagues could, as anthropologists, follow him here d the trend of comparative psychology is to the conary. They would also hold that he misconceives curnt views of the character of organic evolution when he ites that this presupposes "a theory of evolution by utation or emergence of new kinds and species, which ay be contrasted with the Darwinian theory of gradual olution, according to which there is only a difference degree between man and the rest of the world." The o-Darwinian view is a theory of evolution by mutan and of the emergence of new kinds or species. Nor biologists seek to minimize the principle that "mony mickle makes a muckle." The author appears to fall ctim here to the transcendentalism that he deplores others, but he is at least explicit as to his beliefs, hich do not affect the lucidity of his admirable critique past and present theory on the nature of culture. In ew of its wide interest it is to be hoped that the Unirsity of Columbia Press will be able to issue a cheaper udents' edition of this book.

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he Tools of Social Science. John Madge. London: Longmans Green & Company, 1953. ix + 308 pp. 25 shillings.

THIS is a quite admirable, even in some respects unique, "survey of social science in action." It is early written, not very technical, and an interesting aluation of the present condition of the tools that ocial scientists have been forging during the last hundred years or so. It gains special significance, although he author nowhere dwells on it, from the generally felt and often expressed urgency of the times. For the fate of man may well depend upon whether the social sciences can win their struggle to cast aside their adolescence in favor of a responsible adulthood. John Madge thinks that they can and he builds a convincing case for it at the end of his careful appraisal of the flaws and limitations, the values and the promise, which today lie in the methods of the reporters on man and his works.

Even the practiced (and thereby jaded) reader of methodological handbooks, which sociologists and social psychologists have been turning out in quantity of late, will, I believe, be pleased with this book, although he may well shy from it at first glance, muttering that he is already acquainted with the difficulties (not to say the hazards) of constructing a respectable social science. He would be well within his rights, too, if he quails at the prospect of reading again the catalogue of sources and techniques which comprise the kit of the social researcher. These, by the way, are described within a philosophical and historical framework which makes even the questionnaire seem almost an exciting adventure.

Beyond the fact that he has poured a good deal of rather old wine into an attractive container, the author has contributed at least one new thing to the discussion, and that is a remarkably frank and illuminating statement of the reason why we cannot postpone any longer the development of significant empirical research in the behavior sciences with the argument that sufficient objectivity cannot be attained. He demonstrates pretty clearly that what is needed is "a radically different approach" to the problem of experimentation—one in which "the human beings who constitute the subject-matter of social science be regarded, not as objects for experimental manipulation, but as participants in what is being planned." In this manner the experiment, as "a miniature form of social action," will lead to an understanding of the dynamics of group life in a measure unattainable by those who insist on a carefully controlled laboratory exercise.

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Letters on Art and Literature. François Mauriac. New York: Philosophical Library, 1953. 120 pp. $3.00.

THE content of this slender volume is even wider than its title. Here the famous French writer and Nobel Prize winner illumines a variety of topics. In addition to art and literature, the discussion turns on great personalities as well as sundry subjects, sacred and profane, ranging from a sublime appreciation of the priesthood to two letters apropos the Scout movement. The result is that we are given not only some shining examples of the author's well-known literary magic but also his evaluation of the work, thought, and character of many of his distinguished contemporaries.

It would be difficult to distil the essence of a work of

this kind. Its value, however, may be gaged by the fact that it throws light on such issues as: (1) Mauriac's attitude toward the late George Bernanos who, he thinks, comes close to Dostoievsky rather than to Tolstoi; (2) his commentary, addressed to Jacques Rivière, on the Claudel-Gide correspondence which appeared in *Le Figaro littéraire*; and (3) the defense (and this will be of particular interest to Americans) against Albert Camus, of his position concerning Garry Davis, the conscientious objector.

Here also in "the crime against Carmen" will be found his views on music and the play as well as on the novel, painting, poetry, and literary style, which, he says, is best achieved by not having any. A profound spiritual quality pervades this book which is studded with little gems of advice. Quotable passages abound and the translator has succeeded in preserving the flavor of the original. It is climaxed with a piercing plea to Jean Cocteau. Here the master shows himself a true, albeit old, *enfant de coeur*, as the skillful, wise, and supreme artist who continues to prescribe and exemplify for French letters the conditions necessary for their permanence and continuity.

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African Education. The Nuffield Foundation and the Colonial Office. Oxford: University Press, 1953. xi + 187 pp. $1.90.

THE impact of a rising African nationalism accompanied by demands for self-government, of the desire effectively to exploit the rich natural resources of the African continent, of the increasing industrialization and urbanization of Africa, of the Soviet threat to the Western World, and of a growing awareness of the importance of human rights in the modern world, has served to focus increasing attention upon the practices and policies employed in the education of Africans. Since no comprehensive study of the subject had been made since the Phelps-Stokes Commission made their reports in the early 1920's, the Nuffield Foundation and the British Colonial Office cosponsored, in 1950, a study of the educational conditions in British West Africa and in British Central and East Africa. This volume, *African Education,* contains the reports of the two study commissions (the Jeffery Commission for West Africa, and the Binns Commission for East and Central Africa), and a summary of the proceedings of a meeting of British and African educational leaders which met to discuss the reports at Cambridge in September, 1952.

Limiting themselves to a consideration of elementary and secondary education, the two commissions and the Cambridge Conference undertook a comprehensive analysis of the situation. The functions of education in British Tropical Africa, the status of educational facilities there at the present time, the problems of adequately financing and staffing a rapidly expanding educational system, the question of an appropriate curriculum, the role of "voluntary" (especially mission) schools, and the matter of adult education are all treat at considerable length.

In general the two commissions and the conferen agreed as to the importance of adult education in ord to prepare Africans for democratic political life on t western model, the value of maintaining integrat tribal cultures, the dangers of the cultural and perso ality disorganization and social disorder arising from t conflict of African and European outlooks and val systems, the necessity of inculcating strong moral stan ards through the instrumentality of the Christian a Muslim religions, the imperative need of raising t standard of living of the African peoples, the impo tance of vocational education (especially agricultura the desirability of encouraging Africans to stay on the farms instead of migrating to the cities, the importan of adequately financing and staffing the enlarging ed cational system, the desirability of using the Engli language as the medium of instruction, and the gro inadequacy of the traditional curricula with their em phasis on rote learning and literary subjects. The repo offered criticisms in trenchant terms. As Sir Phil Morris, chairman of the Cambridge Conference put i

> The main criticisms of African education were two. O was that there was too little education; too few childre had a chance of any schooling at all, and of those fe too small a proportion carried their schooling to the sta at which it would be really useful to them. The oth criticism was that the education was effective in breakin up (sic) the old African life, but not in adapting its pupi to the conditions of the new. It was bookish, divorce from reality, and gave its pupils a distaste for manu work and for rural life.

The reports are highly critical of the literary edu cation which has prepared Africans primarily for th relatively lucrative government positions, and they plac great emphasis on the importance of vocational edu cation (particularly agricultural), and on religious an moral training as a means of stabilizing African trib life, and stopping the drift toward the towns, whic they view as fraught with evil consequences for both th Africans and the Europeans. They fail to come to grip with, or even to mention, the basic economic problem Increasing agricultural productivity through agricultura education can be at best but a palliative in a situatio where, as in Kenya, European settlers have taken th best lands and have pushed the Africans back upo overcrowded unproductive areas. In discouraging urban ization, and in viewing with alarm the industrializatio of Africa, the educators are, one might suspect, fruit lessly opposing larger social forces, and they fail to se that industrialization is necessary if the standard o living in Africa is to be raised to any considerable exten (It should be noted, however, that the reports urge tha steps be taken to see that such industrialization an urbanization as do occur are not accompanied by th blighting effects of the early Industrial Revolution i England.) One can, of course, scarcely take issue wit the reports' goals of social stability, integrated culture and personalities, and raised economic levels. But thei program of moral and religious training, industrial edu

ion, and rural life does not appear to meet the lities of the situation. They are pervaded with a sense noblesse oblige for what are perhaps people of a er order. Self-government for African peoples is a fessed aim of these educational leaders and colonial ministrators, but self-government in a rather comably distant future.

Although the Binns report and the Cambridge conence conceded, and in fact urged the desirability (if the practicability of large scale) interracial educa-n, the Jeffery report refers to "deep" differences of ial temperament, (p. 7), and elsewhere implies iquated anthropological notions as to the nature of ial differences. The Binns report constantly refers to Africans as "young peoples," needing a helping d. These attitudes are reminiscent of American itudes of fifty years ago, with respect to ways to uplift "young" and "backward" people—the American groes.

African Education is an important document. It is minating both on the status of African education ay, and on the outlook of British educational and onial officials with regard to this important problem.

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k University
hville, Tennessee

ence in Progress. George A. Baitsell, Ed. New Haven: Yale University Press, 1953. xiv + 285 pp. Illus. $6.00.

THE lectures contained in this volume are already more or less familiar to readers of *The American entist.* Their titles and authors are as follows:

1. The Origin and Evolution of the Universe, by G. Gamow.
2. Unsolved Problems of the Sun's Atmosphere, by Walter Orr Roberts.
3. The Earth's Atmosphere, by Joseph Kaplan.
4. The Geological History and Evolution of Insects, by F. M. Carpenter.
5. Africa and the Origin of Man, by D. M. S. Watson.
6. Sensory Physiology and the Orientation of Animals, by Donald R. Griffin.
7. Cooperation and Conflict Among Primitive Organisms, by Paul R. Burkholder.
8. Luminiscent Organisms, by E. Newton Harvey.
9. Microwave Spectroscopy, by Charles H. Townes.
10. Molecular Interactions in Protein Solutions, by George Scatchard.

A preface by the editor gives brief sketches of the turers.

The several lectures are all of high quality, both in bject matter and in presentation. They differ from usual scientific paper in that, first, they are comprensible to the educated nonspecialist and, second, they forth the methods, procedures, and reasoning used. e times allotted to the presentation of papers in the etings of scientific societies are ordinarily so limited t authors are seldom able to give enough of background and significance to be understood by any but his fellow specialists, or to tell the stories of the unfolding of the subjects. Consequently, the average layman is not made conscious of how scientists work, and thinks of the contributions of science too exclusively in terms of material things, the "better living through chemistry," and seldom hears the stories of endeavor and discovery. This volume is a notable contribution to the literature of how scientists work. The topics themselves have been well selected, dealing as they do with discoveries upon matters of intrinsic interest, which intelligent readers can understand without the aid of specialized knowledge.

The book is richly illustrated. Some of the 264 figures give the reviewer his only excuse for adverse comment. One wonders why a lecturer should take pains to prepare lantern slides to explain his subject and then conceal part of it in letters too small and slender to be visible to people not in the front rows. As reproduced in the book, some of the letters are not more than half a millimeter in height, and many are less than one millimeter. The publisher has added his contribution to illegibility by printing the legends under the figures in 5-point type. The reviewer has pretty good eyes for his age, but why not make reading a pleasure, even to the far-sighted?

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Research Operations in Industry. David B. Hertz, Ed. New York: King's Crown Press, 1953. xiv + 453 pp. $8.50.

THE subject matter of this book deals with the manner in which modern research may be organized, planned, and conducted, as differentiated from that type of chance development and sporadic individual effort so prevalent in the past. Text and discussion are from papers delivered by industrial and educational representatives to the Annual Conferences on Industrial Research at Columbia University.

Although basic trends and actions within a specific industry may determine the type and pattern of its research program, the participants agree that the essential components for such a program may be clearly defined in their most important factors. The responsibility of management to the program, what it expects to gain, the selection of adequate personnel and their function in an integrated effort, and important considerations in the physical layout, are among the topics interestingly and informatively brought out in the papers.

Much of the discussion is devoted to defining the meaning and structure of research; viewpoints and opinions take numerous forms such as, "the seeking for information that is not known to the seeker at the time he is seeking it," the desire to change the empirical to fundamental law, "to protect, maintain, and improve the company's position in business." A few evaluations might well be tempered with the realization that much that is considered research is only the fulfillment of

daily tasks. Service functions are rarely of research calibre.

This structure of the book leads one to question the adequacy of the title; rather, the book might bear the name, "Planning for Research Operations" or other more connotative designation. There are no direct and detailed references to projects.

Mitchell's paper, "Management's Appraisal of Industrial Research," might well have been placed in a separate section termed "Personnel Management." His knowledge of human psychology, and his apparent ability to impart a high degree of enthusiasm to his fellow workers, could well be a pattern for anyone desiring to get a job done, be it research or the normal run of daily matters.

Much of the book should prove useful as an aid to organized thinking and clarification of principles relating to correlated research, through which research we have the surest approach to our future industrial and national welfare. There must be scientific discoveries to maintain and expand our productivity.

JAY N. EDMONDSON
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New Screen Techniques. Martin Quigley, Jr., Ed. New York: Quigley Pub. Co., 1953. 208 pp. Illus. $4.50

THREE-DIMENSIONAL, stereoscopic pictures (3-D), wide screen films (W-S), stereoscopic sound (S-S)—these three techniques, as Alfred N. Goldsmith states in his preface to this book, are all old and thoroughly understood. Yet in the year 1953 they have combined to throw Hollywood into a frantic competitive effort to develop "the perfect story-telling medium," the weapon that is to slay the TV dragon.

One glance at the contents page of *New Screen Techniques* is enough to proclaim the book a necessity for all the picture-makers, promoters, exhibitors, and investors in the industry. It is in the same category for "vis. ed." teachers, professors of optical physics, writers, and lecturers on the film industry, and perhaps above all for movie critics.

This is not to imply that we have here a perfect book, but we do have all that all the experts know about the new screen techniques. In twenty-six illustrated articles there is unavoidable duplication, for here speak eagerly the voices of leading technicians, inventors, research men, camera men, executives, and promotion wizards of the movie industry. If some of them are careful to set down (with dates and data) their own contributions to this cinematic revolution, well, have they not earned the right to plant their milestones on the long, long road that has brought us from the nickelodeon to the drive-in?

What do they say, and who says so? This reviewer has no intention of diving into the melee of well-armed technical experts, especially in a review of this length. In brief, Part I presents ten authors, among them John A. Norling, Herbert T. Kalmus, and M. L. Gunzburg, writing on 3-D. Here the Anaglyph (red a green specs, please) crosses rapiers with the Polaro technique, the swordplay being usually at street lev though sometimes it ranges to technical peaks, espe ally in the Polaroid regions.

In Part II the fascinating story of Cinerama, fro World War II gunnery trainer to Broadway sensati is covered by the five men who had most to do with it covered entertainingly and well.

Cinerama is followed by Cinemascope (eight writ on wide-screen vision and stereo-sound); and af them march three experts on other wide-screen tec niques, such as the anamorphoser, which uses a cyli drical lens to compress a wide picture to normal fil width, and a similar projector lens that expands t image onto a wide screen.

That's the book. For many it will be fascinating, a perhaps for a few physicists, inventors, and invest this slim volume might lead toward fame or fortune, Hollywood and Vine becomes once more the center the world of shadows—a new world of moving, talki colored, three-dimensional shadows.

Subsequent to the reading of *New Screen Techniqu* came a sobering glimpse of the tough realities of t industry in the *New York Times* (Oct. 13, 1953), whe Thomas M. Pryor wrote under a Hollywood datelin "The optimism with which the movie business w viewing a golden three-dimensional future earlier the year now appears to have turned to pessimism. recent weeks exhibitors in widely scattered sections the country have taken to using the slogan, '2-D, glasses needed,' in advertising copy, and box-office r ports published in such trade papers as *Daily Vari* and *The Hollywood Reporter* show disappointing r sults for 3-D attractions currently on the market.

"The only spark of hope evidenced in produci circles is that the present display of public rejection based on the quality of the pictures rather than on t medium of stereoscopic photography as such.

"The general attitude in Hollywood is that enthusias for a quick dollar led the industry into the three-dime sional field without the proper kind of technical prep ration. But this sort of hindsight knowledge holds litt comfort for a business which, according to a compil tion by *The Hollywood Reporter*, has an investment approximately $21,000,000 in unreleased three-dime sional attractions. Of course, the investment is saf guarded to the extent that all these pictures can shown in the conventional manner.

"The ironic part of the failing drawing power of 3- pictures is that it comes at a time when very defini improvement is being made in this line of endeav all the way from the manufacturer of the Polaro viewing spectacles to techniques in photography an projection."[1]

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[1] Reprinted with permission of the *New York Times.*

A Bibliography on Meteorites. Harrison Brown, Ed. Chicago: University of Chicago Press, 1953. viii + 686 pp. $10.00.

THIS book is primarily the bibliography for a two-volume work that is yet to be published. Unless it is considered in this light, its importance and usefulness are likely to be underestimated.

In view of the approximately 25,000 reference listings from over 1900 sources that this bibliography contains, it would appear that substantial progress has been made in the dissemination of knowledge concerning meteoritics since Thomas Jefferson's famous statement (on the occasion of a reported meteorite fall in Weston, Connecticut, 1807 December 14/26), "I could more easily believe that two Yankee professors would lie than that stones would fall from heaven." Actually, there are 343 major listings in the bibliography that antedate the Weston, Connecticut, fall.

The book consists of three parts. In the first section the editors have done a comprehensive job of compiling 8650 major reference listings from the literature of the world for the period 1491–1950. The entries are grouped chronologically by year. For each year, the tabulation is alphabetical by author. Each main listing is followed by an enumeration of any abstracts, translations, and reviews, and it is these that bring the total to 25,000.

Although no original Greek or Roman essays or descriptions are included in the bibliography, translations of early works have been listed. The first entry reads in part: "Plutarchus. Description of the stone fall near Egos Potamos in 462 B.C. (in Latin). . . ." There are two references to Aristotle and four to Pliny.

The second section contains an alphabetical list of the authors whose names appear in section one. Under each author's name are tabulated his contributions by code number from the first section. From the viewpoint of sheer prolificness, S. Meunier heads this list. In the course of the 58 years from 1867–1925 he published 162 papers. During the 35 years from 1867 to 1902, only 1877 transpired without the appearance in print of at least one title.

The third section of the book is a journal index. The references of section one were extracted from 1068 journals, magazines, and newspapers, in addition to 840 books, monographs, pamphlets, catalogues, and correspondence items.

Those interested in the phenomena of meteors will be disappointed that the bibliography does not include meteorics. The task planned and accomplished for meteorites alone, however, is obviously a pretentious one.

The utility of the present volume may seem to be limited by the procedure of listing chronologically and by author rather than by subject. The editor states, however, that in the near future, two additional volumes will be published containing alphabetical, chronological, and geographical indexes of all meteorites; descriptions, chemical analyses, and tables of locations of meteorites in collections; and an index to general subjects related to meteorites. In these two subsequent volumes, references to listings in this bibliography will be by code number only. At such time as Volumes II and III appear, the importance and usefulness of the present volume will be greatly increased.

JOHN A. RUSSELL
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Reviews of Research on Arid Zone Hydrology. Paris: UNESCO; New York: Columbia Univ. Press, 1953. 212 pp. + maps. $5.00.

THIS compilation of reports of research was published by UNESCO in Paris, France, in 1953. The typography and copy editing are good. The book has eight regional reports, each prepared by an expert commissioned by UNESCO. In general, each report states the problem of its region, defines the pertinent areas, describes the climate, physiography and hydrogeology, and discusses current practices, recent research in fluid mechanics and plans for future development. The combined bibliographies total 1600 citations. Individual reports differ somewhat from the prototype, as outlined below, where each writer is identified with the area for which he reported.

Northwest Africa, Georges Drouhin, largely descriptive, with recommendations for advancing the knowledge of the area and its aquifers.

Northeast Africa, Y. M. Simaika, research in sedimentation and scour of irrigation channels, measurement of very low velocities in small channels, and unsteady flow at transition sections.

Union of South Africa and Angola, H. F. Frommurze, characteristics of the aquifers, quality of water, and methods of prospecting.

Middle East, Nazmi Karatekin, tabulation of period of record and characteristic statistics of streamflow for many important streams.

India and Pakistan, R. D. Dhir, storage and transmission losses in reservoirs and canals, ground-water prospecting in various regions, types of wells and methods of pumping, and water quality.

United States and Canada, R. K. Linsley, emphasis on analytical techniques, summarizes many new findings having general applicability.

Latin America, Guillermo A. Fernandez de Lara, largely descriptive, geographic features, water resources, and hydrologic research of each nation.

Australia, E. Sherbon Hills, source, special conditions, quality and temperature of ground water in various localities.

In addition to several regional maps, there are two hemispherical homoclimatic maps compiled by Peveril Meigs with a brief supporting text in which he describes an effective and convenient classification of precipitation and temperature regimes of arid zones.

The volume is written in simple English, yet it is highly informative and authoritative. Unfortunately,

some important arid areas are not represented. In view of the present world political situation, the publication of this volume is a particularly significant and impressive step in a scientific approach to problems of great importance to the people of the world.

WALTER T. WILSON

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The Limits of the Earth. Fairfield Osborne. Boston: Little, Brown and Co., 1953. x + 238 pp. $3.50.

FAIRFIELD OSBORNE has such a broad understanding of natural resource problems and the ability to appraise them so keenly that his discussion of potential world food supplies versus the growth in world population as of 1975 makes interesting and instructive reading. He relates briefly the story of the great periods in history and the interrelation between forests, water supply, and fertile soils, the flourishing of nations in business and culture when resources were more than sufficient to answer basic needs, and the fall of nations when resources became over-exploited.

Although all natural resources have been considered, the theme of the book pertains primarily to food supplies. In a most fascinating and factual way the author analyzes the limits for agricultural development in Australia, Canada, Argentine, United States, South Africa, and the Amazon valley. He takes into account the soil, climate, rainfall, possible scientific improvements, and other necessary conditions for increasing crop yields and expanding production. The delusion that these countries can support huge increases in population is made very clear. The author has not neglected to discuss critically the potentialities of food from the sea, in the form of fish or marine algae and plants.

He recognizes the capabilities of scientists but is dubious whether their contributions will have significant effect upon the food problem. Perhaps he is justified in such a conclusion. A large percentage of the people of the world are now undernourished. With the food supply increasing by 9% while the population is increasing by 12%, the situation in a few decades will become critical.

The natural conclusion is reached that only by population control will it be possible to have a stable and happy world. He cites the experiment in population control in Sweden, which has no parallel elsewhere. The program is based on three principles: democracy implies voluntary parenthood and the right of the citizen to decide what his family should be; the quantity of population should not be bought at the expense of quality; and the social and economic resources of society should be utilized to assure the maximum welfare of the maximum number of people.

This book is provocative in that it provides a multitude of facts and many different settings. It gives the reader freedom to draw his own conclusions rather than necessarily to follow what the author may indicate as his own opinion.

ROGER ADAMS

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Books Reviewed in SCIENCE

February 5

Ascidians of Sagami Bay. Described and illustrated by Takasi Tokioka; Hirotaro Hattori, Ed. Tokyo: Iwanami Shoten, 1953. 315 pp. 79 plates. 2500 yen.
Reviewed by N. J. Berrill.

The Neurophysiological Basis of Mind: The Principles of Neurophysiology. John Carew Eccles. New York: Oxford Univ. Press, 1953. 314 pp. Illus. $6.50.
Reviewed by E. Gellhorn.

Advances in Carbohydrate Chemistry, Vol. 7. Claude S. Hudson *et al.,* Eds. New York: Academic Press, 1952. 370 pp. $7.50.
Reviewed by Ralph C. Corley.

February 12

Advances in Enzymology and Related Subjects of Biochemistry, Vol. XIV. F. F. Nord, Ed. New York: Interscience, 1953. 470 pp. incl. cumulative index. Illus. $9.25.
Reviewed by B. L. Horecker.

February 26

Proceedings of the First International Congress of Electron Microscopy. Paris: Editions de la Revue d'Optique, 1953. 768 pp. Illus. $23.75.
Reviewed by Thomas F. Anderson.

Organic Chemistry: An Advanced Treatise, Vols. III and IV. Henry Gilman, Ed. New York: Wiley; London: Chapman & Hall, 1953. 1245 pp., illus. + indexes. $8.75 a volume.
Reviewed by Wallace R. Brode.

Science in Alaska, 1951. Proceedings of the Second Alaskan Science Conference, AAAS, Alaska Division, 1953. (Order from: Dr. Troy L. Péwé, Box 4004, College, Alaska.) 362 pp. $3.00.
Reviewed by Ira N. Gabrielson.

Small Particle Statistics. Gustan Herdan; with a guide to the experimental design of particle size determinations by M. L. Smith. Amsterdam-Houston: Elsevier, 1953. 520 pp. Illus. $12.00.
Reviewed by D. ter Haar.

ASSOCIATION AFFAIRS

A REPORT OF THE BOSTON MEETING

THE report of a large scientific meeting serves several useful purposes. It provides a record of those data and highlights by which a meeting can be appraised or compared, and it may call attention to events of more than transient importance. Those who attended the meeting are reminded of their personal impressions; those who were not there may be informed of what was missed, and may be prompted to plan to attend another time.

The 120th meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE takes its place in the annals as one of the best in all respects. Favored by mild pleasant weather throughout, characterized by really good programs in all principal sciences, and noteworthy for the uniformly high level of friendly cooperation on the part of the local members and friends of the Association, this meeting continued in the rich vein of hospitality and interest manifested in the six prior meetings in Boston, as described in an earlier article [*The Scientific Monthly* **77**, 116 (1953)]. The local committee entertained the board of directors and administrative staff of the Association at a buffet supper; dinners and other social events arranged by the sections and societies were numerous, and many resident scientists invited out-of-town speakers and colleagues to their homes. Both in paid regristrations, 3315, and in other measured attendance, this was the largest AAAS Boston meeting by a substantial margin.

The meeting had sessions of all types, and in good balance. No principal field of science was neglected. There were programs for specialists, arranged by large societies holding their national meetings with the Association and also by some of the AAAS sections. And there were symposia that were in areas between, or embracing, several scientific disciplines. There were all the features expected at AAAS meetings—outstanding general addresses by eminent leaders in science, the latest scientific films, a large-scale series of exhibits, a "Biologists' Smoker" with refreshments, open to all registrants. There were conferences on problems of the academies, on editorial matters, on scientific manpower; and there was a penetrating, able consideration of the position of scientists in American society today. All these aspects of the 120th meeting deserve more than passing attention.

General symposia. Early in March, 1953, the AAAS symposium committee, appointed by President Condon for that year, met to decide the theme of the 120th meeting, "Scientific Resources for Freedom," and to settle upon one or more general symposia to be sponsored by the Association as a whole. Three programs and the persons to implement them were decided upon, nearly ten months before this Boston meeting. The sound judgment of the committee was demonstrated and fulfilled when all three programs were received by appreciative audiences that usually filled, and upon occasion, overflowed, the large Paul Revere Auditorium of Mechanics Building.

The first of these symposia was on the topic, *Species which feed mankind.* Given in two parts, it served to focus attention on the relatively small number of plant and animal species that form the staple foods of the world's populations and on some of the diverse technical problems of maintaining these species in adequate supply.

The two sessions of the second symposium, on *The sea frontier,* brought together in one program a most interesting diversity of papers on the geologic, oceanographic, engineering, and food-resource aspects of the margin or interface where land and sea meet. The speakers, all eminent authorities in their fields, complemented one another's reports so that this proved to be one of the most successful interdisciplinary general symposia in recent years.

The two parts of *The scientist in American society,* were independently conceived and arranged, respectively, by Section K and a subcommittee of the AAAS symposium committee. Dr. Weisskopf spoke in place of Dr. Urey who, at the last minute, found that, to accept an award, he had to delay his arrival in Boston one day. The thoughtful well-delivered papers of this program, devoted to the general area of freedom for scientific inquiry in today's troubled world, pleased the large and responsive audience.

Other symposia. Although several of the sections decided to have fewer and more definitive symposia at Boston, the total number, including groups of invited papers on specified subjects, arranged by the sections and subsections, was 41 (comprising 65 sessions, an average of 1.6 sessions each). With the 19 additional one-session symposia arranged by 12 of the participating organizations and the Association's general symposia, necessarily largely concentrated on four days, there was, as usual, an embarrassment of riches.

The general problem of how many symposia may be ideal for an AAAS meeting is uncertain. A technical symposium on a subject such as *Radio astronomy* will not compete with another specialized program, such as *Antimetabolites and cancer,* even if scheduled concurrently. On the other hand, all sessions of any sort are in potential and mutual conflict with any broad program planned to appeal to a large proportion of the entire attendance. The pattern of scheduling specialized symposia and sessions for contributed papers in the mornings, the broader and interdisciplinary symposia in the afternoons, and the most general events in the evening, although followed in the main, cannot be completely realized because of the logical wish of each group to hold a two- or three-session symposium on a single day, and the tendency of the participating societies to arrange their sessions so that their memberships will have a minimum number of nights for which to pay for

sleeping accommodations. Experience has shown, however, that if the total attendance at the meeting is sufficient, both the specialized and the general programs will have audiences considered satisfactory by those who arranged them; in any event, each program chairman or presiding officer has the satisfaction of knowing that every nonspeaker present in the room, confronted by many alternatives, has *chosen* to attend his session. At Boston, it is believed that most symposia had an adequate attendance and, indeed, capacity audiences were common.

Conferences. Among the growing number of conferences at AAAS meetings, the *Academy conference* again broke an attendance record, the *Conference on scientific manpower III* held three important sessions, and the *Conference on scientific editorial problems II* evoked so much interest that it plans multiple sessions for 1954. Of unique importance was the *Conference on the validation of scientific theories*, sponsored by the National Science Foundation and held, principally, at the American Academy of Sciences.

Special sessions. The special sessions, which add so much to the meetings each year, without exception attracted large and appreciative audiences. Too late for change in the General Program-Directory, the National Geographic Society's Illustrated Lecture, instead of the speaker listed, was given by Volkmar Wentzel, staff member, on the subject "Into the heart of free Africa." Jointly with the AAAS, the Society of the Sigma Xi sponsored the scholarly, amusingly anecdotal address, "The design and mechanism of muscle," by A. V. Hill, recent past president of the British Association. The thoughtful and timely address of AAAS retiring president, Detlev W. Bronk, was devoted to "The role of scientists in the furtherance of science." He was preceded by the general chairman Earl P. Stevenson, who welcomed the AAAS to Boston with well-chosen and gracious remarks. At the fifth of the annual addresses of the Scientific Research Society of America, a great authority on suspension bridges, David B. Steinman, spoke on "Suspension bridges—The aerodynamic problem and its solution;" and it was announced that he was the recipient of the Society's William Procter Prize for 1953. The Phi Beta Kappa address of Leonard Carmichael, "Science and social conservatism," concluded this splendid series of special sessions of the 1953 AAAS meeting.

Business sessions. In accordance with the Constitution, the Board of Directors of the Association held one of its four regular meetings of the year at Boston, its sessions preceding the two sessions of the Council. A gratifying number of council members were present to elect the new officers of the Association, to hear and to accept Detlev Bronk's report of an eventful year, and to take action on committees, one of which will immediately undertake a study of the operation of the Association under the present Constitution and Bylaws and report at the next meeting of the Council, December 1954, in Berkeley, California. With the filling of the vacancies in the enlarged administrative staff, the Association, now well into its 106th year, stands on the threshold of new opportunities to be of service to science and to society.

Analysis of sessions. In addition to the 18 sections and subsections of the Association, all of which had one or more sessions (for a total of 104), 63 societies and other organizations officially participated in the Boston meeting. Of this number, 16 societies had national meetings, their sessions totaled 102; 24 had regional meetings, with 45 sessions; and the remaining 23 organizations were official cosponsors of programs arranged by AAAS sections or other societies. An analysis of the 265 sessions appears in Table 1.

TABLE 1. Analysis of sessions at the Boston meeting.

Sessions for contributed papers	71
Sessions of symposia	88
Sessions of conferences	10
Roundtable sessions	15
Business sessions	36
Meal functions (often with addresses)	30
Other sessions with addresses	15
Total number of sessions	265

The total of 1095 speakers on the program does not include junior authors of many of the contributed papers, 123 papers read by title, or presiding officers, unless remarks by them were listed in the programs.

Attendance. At any annual meeting of the Association, the total number of persons who attend some session or phase of the convention, or who see the large-scale Annual Exposition of Science and Industry, typically exceeds 10,000, and this was true at the seventh Boston meeting. As for the number of registrations, the number exceeded that for the sixth Boston meeting of 1946 by 579, or 21 percent. Although 53 percent of the attendance came from the six New England states, it was a truly national meeting like its predecessors. There were registrants from all but three states of the nation (Idaho, Nevada, Wyoming), as Table 2 shows. More than at any meeting in recent years, there was a substantial number of distinguished foreign scientists in attendance. In addition to 29 speakers and presiding officers from all parts of Canada, there were 21 scientists from eight foreign countries who actively participated in the programs. Dr. H. P. A. de Boom officially represented the South African AAS and, as noted, Dr. A. V. Hill, recent past president of the British Association, gave an address cosponsored by the AAAS and the Society of the Sigma Xi.

A statistical breakdown of the 3315 registration slips, grouping "Fields of interest," appears in Table 3. Of the 7250 adults who deposited cards of complimentary admission to the Exposition, about half, or 3501, also indicated their fields of interest (Table 3).

Work of the local committees. As must be apparent to all members of the Association, it would be quite impossible successfully to arrange a large and complex AAAS meeting, to carry it through to a satisfactory conclusion, and, indeed, to finance it, were it not for the genuine interest and effective personal services of

ocal members and friends of the Association. Thus, in very real sense, the success of the seventh Boston meeting is attributable to the sound advice and substantial ersonal attention of the general chairman, Earl P. tevenson, president, Arthur D. Little, Inc., and of hose whom he asked to serve. It is noteworthy that Dr. tevenson accepted this responsibility in the fall of 952, attended and studied the operation of the St. ouis meeting, appointed his committees early in 1953, nd maintained close touch with all developments until he books of the meeting were closed last month. On ehalf of the officers and members of the Association, nd for himself, the writer expresses deep appreciation o Dr. Stevenson; and also to vice chairman Walter S. aird, president of Baird Associates, Inc., who headed he Exhibits Committee; Carlton P. Fuller, vice president of Polaroid Corporation, chairman of the finance ommittee; Wallace Dickson, director of public relations, The New England Council, chairman of the ublic relations committee; Carl M. F. Peterson, superintendent of buildings and power, M.I.T., who accepted he responsibility of directing the service committee; nd to each member of all local committees. An expression of grateful appreciation is particularly due Warren S. Berg, Arthur D. Little, Inc., who served as executive ecretary of the local committees with unfailing enthusiasm and efficiency throughout the year; and Donald D. Hathaway, Baird Associates, Inc., who served so ffectively as secretary of the exhibits committee.

AAAS science theatre. In seven programs, each four hours long, 40 of the latest foreign and domestic films were presented to appreciative audiences that consistently filled the improvised room of 300 capacity in the Mechanics Building. Most titles, nearly all in color and with sound, were shown twice. The Association again expresses its appreciation to those who so kindly lent such excellent films.

Annual exposition of science and industry. In addition to some 3300 registrants, 7250 science-minded adults deposited complimentary cards of admission and saw one of the best expositions ever sponsored by the Association. The 95 exhibitors and 153 booths—exhibiting the latest in scientific books, instruments, and materials used by scientists—occupied some 30,000 square feet in the main exhibition hall of the venerable Mechanics Building. There were individual industrial exhibits ranging from transistors to a great jet engine, and others from water fleas to live chimpanzees. Nearly half of the exhibit space was developed as a "New England Section," with special decorations in prismatic colors (which were financed by premium rentals and special contributions). This section featured the latest technological developments in this area, and both enriched the Show and assisted materially in financing the meeting.

Industrial firms with booth space in the Annual Exposition of Science and Industry, not mentioned in

TABLE 2. Distribution of registrants by states and countries.

Alabama	6	Oklahoma	6
Arizona	1	Oregon	1
Arkansas	2	Pennsylvania	148
California	46	Rhode Island	86
Colorado	4	South Carolina	7
Connecticut	177	South Dakota	2
Delaware	10	Tennessee	32
District of Columbia	99	Texas	24
Florida	22	Utah	5
Georgia	11	Vermont	22
Illinois	76	Virginia	44
Indiana	41	Washington	4
Iowa	21	West Virginia	8
Kansas	6	Wisconsin	13
Kentucky	7	Total, U.S.	3252
Louisiana	14		
Maine	58	Alaska	2
Maryland	99	Argentina	1
Massachusetts	1354	Australia	1
Michigan	55	Brazil	1
Minnesota	17	British West Indies	1
Mississippi	2	Canada	43
Missouri	20	Ceylon	1
Montana	4	Colombia	1
Nebraska	12	Cuba	2
New Hampshire	49	England	4
New Jersey	130	Hawaii	2
New Mexico	3	Mexico	1
New York	424	Pakistan	1
North Carolina	21	Scotland	2
North Dakota	1		
Ohio	58	Total Registration	3315

TABLE 3. Subject fields of attendance.

	Regis-trants	Compli-mentary admissions	Total
Mathematics	28	23	51
Physical sciences			
Physics	191	863	1054
Meteorology	24	21	45
Chemistry	228	264	492
Astronomy	33	21	54
Geology and geography	110	73	183
Geophysics	37	10	47
Engineering	83	533	616
Biological Sciences			
Botany and plant physiology	163	20	183
Genetics	236	5	241
Zoological sciences	465	22	487
Other biology	299	54	353
Agriculture	41	35	76
Medical Sciences			
Biochemistry and nutrition	130	28	158
Physiology	121	16	137
Dental research	29	9	38
Pharmacy	75	10	85
Other medicine	262	217	479
Psychology	164	53	217
Anthropology and archaeology	63	18	81
Economic and social sciences	49	34	83
History and philosophy of science	28	9	37
Science teaching and education	177	103	280
General	279	1060	1339
Total	3315	3501	6816

either the 1953 General Program-Directory or in the Preconvention Issue of *Science*, were:

Air Reduction Sales Corporation
Alden Products
Cambridge Corporation
Hood Rubber Company
F. C. Meichsner Company
Transistor Products, Inc.

As planned originally, the New England Section, in particular, included a most interesting series of exhibits of nonprofit organizations. The booths these occupied were sponsored principally by local companies who did not find it convenient to exhibit but who wished to support the meeting, but there were three exhibitors among those who endowed booth space or made outright contributions. Organizations with sponsored booth space in the Annual Exposition of Science and Industry, not mentioned in either the 1953 General Program-Directory or in the Preconvention Issue of *Science*, were:

Air Force Cambridge Research Center
Amateur Telescope Makers of Boston
American Academy of Arts and Sciences
Arnold Arboretum
Boston Public Library
Boston Symphony Orchestra
Boston University
Christian Science Monitor
Federation of American Scientists
Harvard University Medical School
Harvard University School of Public Health (specifically endowed by the Kendall Company)
Massachusetts Institute of Technology
New England Council
Tufts College
U. S. Army, Watertown Arsenal
Weston College
Woods Hole Oceanographic Institution

Companies contributing to the Boston meeting of the Association were:

Godfrey L. Cabot, Inc. (exhibitor also)
Comstock & Wescott, Inc.
Dennison Manufacturing Company
Dewey and Almy Chemical Company
Draper Corporation
The Foxboro Company
Gamewell Company
John Hancock Mutual Life Insurance Company
Carl Heinrich Company
Howe & French, Inc.
Jarrel-Ash Company
Jenney Manufacturing Co.
Kendall Company, Bauer & Black Division
Arthur D. Little, Inc. (exhibitor also)
Chas. T. Main, Inc.
Monsanto Chemical Company (exhibitor also)
New England Gas and Electric System
Norton Company
Pitney-Bowes, Inc.
Saco-Lowell Shops
Sprague Electric Company
United Aircraft Corporation
United-Carr Fastener Corporation
United Shoe Machinery Corp.
Whitin Machine Works

Their generous contributions are gratefully acknowledged.

A more comprehensive account of the Boston meeting and a complete directory of all Association officers for 1954 appeared in the February 19 issue of *Science*.

RAYMOND L. TAYLOR
Associate Administrative Secretary

New Books Received

Preparation for Medical Education in the Liberal Arts College. The report of the subcommittee on professional education of the Survey of Medical Education. Aura E. Severinghaus, H. J. Carman, and W. E. Cadbury. New York: McGraw-Hill, 1953. xxiv + 400 pp. $4.50.

Westward Ho with the Albatross. Hans Pettersson. New York: Dutton, 1953. 218 pp. Illus. + plates. $4.00.

Woodworking for the Home Craftsman. Emanuele Stieri. New York: Barnes & Noble, 1953. vii + 376 pp. Illus. $1.50.

Augustine to Galileo. The History of Science A.D. 400–1650. A. C. Crombie. Cambridge, Mass.: Harvard Univ. Press, 1953. xv + 436 pp. Illus. + plates. $8.00.

Galatheas Jordomsejling 1950–52. A. F. Bruun *et al.*, Eds. Copenhagen, Denmark: J. H. Schultz Forlag, 1953. 307 pp. Illus. + map.

Math is Fun. Joseph Degrazia. New York: Emerson Books, 1954. 159 pp. Illus. $2.75.

Thomas Jefferson's Farm Book. With commentary and relevant extracts from other writings. Edwin Morris Betts, Ed. Princeton, N. J.: Princeton Univ. Press, 1953. For the American Philosophical Society. xxiii + 552 pp. Illus. + plates. $15.00.

An American in Europe. The life of Benjamin Thompson, Count Rumford. Egon Larsen. New York: Philosophical Library, 1953. 224 pp. $4.75.

Fundamentals of Reservoir Engineering. John C. Calhoun, Jr. Norman, Okla.: Univ. of Oklahoma Press, 1953. xvi + 417 pp. Illus. $6.00.

High Altitude Rocket Research. Homer E. Newell, Jr. New York: Academic Press, 1953. xiv + 298 pp. Illus. $7.50.

The Integration of Behavior, Vol. II. The integrative process in dreams. Thomas M. French. Chicago, Ill.: Univ. of Chicago Press, 1954. xi + 248 pp. $6.50.

The Pocket History of Freemasonry. Fred L. Pick and G. Norman Knight. New York: Philosophical Library, 1953. 294 pp. $4.75.

Principles of Polymer Chemistry. Paul J. Flory. Ithaca, N. Y.: Cornell Univ. Press, 1953. xvi + 672 pp. Illus. $8.50.

Science and Man's Behavior. The contribution of phylobiology. Trigant Burrow. William E. Galt, Ed. New York: Philosophical Library, 1953. xii + 564 pp. $6.00.

The American Sexual Tragedy. Albert Ellis. New York: Twayne Publishers, 1954. 288 pp. $4.50.

Cultural Patterns and Technical Change. Margaret Mead, Ed. Paris: UNESCO; New York: Columbia Univ. Press, 1953. 348 pp. $1.75.

Curious Creatures. Erna Pinner. New York: Philosophical Library, 1953. 256 pp. Illus. $4.75.

The Effect of ACTH and Cortisone upon Infection and Resistance. Gregory Shwartzman, Ed. New York: Columbia Univ. Press, 1953. 204 pp. Illus. $5.50.

Faster than Thought. A symposium on digital computing machines. B. V. Bowden, Ed. London–New York: Pitman, 1953. xix + 416 pp. Illus. + plates. 35/.

The Fundamentals of World Peace. A. Hamer Hall. New York: Philosophical Library, 1953. 112 pp. $3.00.

Paying for Medical Care in the United States. Oscar N. Serbein, Jr. New York: Columbia Univ. Press, 1953. xxiv + 543 pp. $7.00.

Meetings

March

11–13. American Orthopsychiatric Assoc., New York, N.Y. (M. F. Langer, 1790 Broadway, New York 19.)

11–13. Kappa Delta Pi, Lafayette, Ind. (E. I. F. Williams, 277 E. Perry St., Tiffin, Ohio.)

11–13. National Wildlife Federation, annual, Chicago Ill. (L. F. Wood, 232 Carroll St., NW, Takoma Park 12, D.C.)

15–19. National Assoc. of Corrosion Engineers, annual, Kansas City, Mo. (A. B. Campbell, 1061 M & M Bldg., Houston 2, Tex.)

16–17. Symposium on Monte Carlo Methods, Gainesville, Fla. (H. A. Meyer, Univ. of Florida, Gainesville.)

18. Inst. of Mathematical Statistics, Eastern regional, Gainesville, Fla. (H. A. Meyer, Univ. of Florida, Gainesville.)

18–20. American Physical Soc., Detroit and Ann Arbor, Mich. (K. K. Darrow, Columbia Univ., New York 27.)

20. The Biochemical Soc., annual, London, Eng. (F. L. Warren, Biochemistry Dept., London Hospital Medical College, London W. 1.)

21. International Assoc. for Dental Research, French Lick, Ind. (E. H. Hatton, 311 E. Chicago Ave., Chicago 11, Ill.)

22–24. American Assoc. of Dental Schools, annual, French Lick Springs, Ind. (M. W. McCrea, 42 S. Greene St., Baltimore, Md.)

22–25. Inst. of Radio Engineers, annual, New York City. (E. K. Gannett, 1 E. 79 St., New York.)

24–1. American Chemical Soc., 125th national, Kansas City, Mo. (R. M. Warren, 1155 16 St., NW, Washington, D.C.

25–27. Alpha Epsilon Delta, 10th national, Bloomington, Ind. (M. L. Moore, 7 Brookside Circle, Bronxville, N. Y.

25–27. Optical Soc. of America, spring, New York City. (A. C. Hardy, Massachusetts Institute of Technology, Cambridge 39.)

25–27. Symposium on the Origins of Resistance to Drugs, Washington, D.C. (M. G. Sevag, Dept. of Microbiology, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)

26–28. American Assoc. of Physical Anthropologists, annual, Yellow Springs, Ohio. (J. L. Angel, Jefferson Medical College, 307 S. 11 St., Philadelphia 7, Pa.)

27–28. American Psychosomatic Soc., 11th annual, New Orleans, La. (APS Office, 551 Madison Ave., New York 22, N. Y.)

April

1–2. American Heart Assoc., 30th annual, Chicago, Ill. (R. Betts, AHA, 44 E. 23 St., New York 10, N. Y.)

1–3. National Science Teachers Assoc., annual, Chicago, Ill. (R. H. Carleton, 1201 16 St., NW, Washington 6, D. C.)

2–3. American Assoc. of University Professors, Buffalo, N. Y. (R. E. Himstead, 1785 Massachusetts Ave., NW, Washington 6, D. C.)

2–3. Assoc. of Geology Teachers, New England Section, 1st annual, Burlington, Vt. (C. G. Doll, Dept. of Geology, Univ. of Vermont, Burlington.)

3–10. Pan American Cong. of Veterinary Medicine, 2nd, São Paulo, Brazil. (J. S. Veiga, Rua Pires da Mota 159, São Paulo.)

5–8. Symposium on Orthopteran Acoustics, Jouy-en-Josas, France. (Laboratoire de Physiologie Acoustique, Institut National de la Recherche Agronomique, Jouy-en-Josas.)

5–10. International Sound-Recording Conf., Paris, France. (Société des Radio-electriciens, 10–14 Avenue Pierre-Larousse, Malakoff, France.)

5–11. Pan American Cong. on Agronomy, 2nd, São Paulo, Brazil. (J. Moraes, Escola Superior de Agricultura "Luiz de Queiroz," Piracicaba, Brazil.)

6–9. Conf. on the Physics of Particle Size Analysis, Nottingham, Eng. (Inst. of Physics, 47 Belgrave Square, London S.W. 1.)

7–9. American Assoc. of Anatomists, Galveston, Tex. (N. L. Hoerr, Western Reserve Univ. School of Medicine, 2109 Adelbert Rd., Cleveland 6, Ohio.)

7–10. Conf. on Luminescence, Cambridge, Eng. (S. T. Henderson, 47 Belgrave Square, London, S.W. 1.)

8–9. European Assoc. against Poliomyelitis, Paris, France. (Secretariat General, 130 Rue de Linthout, Brussels, Belgium.)

9–10. Eastern Psychological Assoc., annual, New York, N. Y. (Gorham Lane, Dept. of Psychology, Univ. of Delaware, Newark.)

9–11. Soc. for Applied Anthropology, New York, N. Y. (Mrs. E. Purcell, 61 W. 55 St., New York 19.)

10–11. American Acad. of Optometry, western regional, Berkeley, Calif. (D. B. Carter, School of Optometry, Univ. of California, Berkeley.)

11–15. American Physiological Soc., Atlantic City, N. J. (M. O. Lee, 2101 Constitution Ave., Washington 25, D. C.)

11–15. Soc. of Exploration Geophysicists, annual, St. Louis, Mo. (B. W. Sorge, c/o United Geophysical Co., Inc., P. O. Box M, Pasadena 15, Calif.)

12–13. Conf. on Diseases in Nature Transmissible from Animal to Man, 4th annual, College Station, Tex. (C. D. Leake, Univ. of Texas Medical Branch, Galveston.)

12–14. American Oil Chemists Soc., 45th annual, San Antonio, Tex. (J. S. Swearingen, Southwest Research Institute, San Antonio 6.)

12–14. International Cong. of Alpine Meteorology, 3rd, Davos, Switzerland. (W. Morikofer, Observatoire physico-meteorologique, Davos.)

12–15. American Assoc. of Petroleum Geologists, St. Louis, Mo. (E. H. Powers, Southern Prod. Co., Box 670, Fort Worth, Tex.)

12–16. Federation of American Societies for Experimental Biology, Atlantic City, N. J. (Miss Dorothy Briggs, 2101 Constitution Ave., Washington 25, D. C.)

12–17. International Cong. on Irrigation and Drainage, 2nd, Algiers, Algeria. (Association Française pour l'Etude des Irrigations et du Drainage, Boite Postale 52, Grenoble, France.)

13–17. American Dermatological Association, White Sulphur Springs, W. Va. (J. L. Callaway, Duke Hospital, Durham, N. C.)

15–17. Assoc. of Southeastern Biologists, annual, Baton Rouge, La. (M. A. Gaulden, Oak Ridge, Tenn.)

16. Seismological Soc. of America, annual, Seattle, Wash. (P. Byerly, 208 Bacon Hall, Univ. of California, Berkeley 4.)

16–17. Histochemical Soc., Atlantic City, N.J. (R. D. Lillie, National Institutes of Health, Bethesda, Md.)